Series 500 FUNCTION GENERATORS

OPERATION & MAINTENANCE MANUAL

SERIES 500

FUNCTION GENERATORS

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SECTION 1

INTRODUCTION

1.1 GENERAL

This manual basically describes the AILTECH Series 500 Function Generators. The text is centered upon the Model 511, a 10 MHz unit with trigger-gate capability. This information is applicable with minor differences to the other models in the series. These differences are described in Section 7, Addendum.

1.2 BASIC DESCRIPTION

1.2.1 The basic model 511 is a high frequency Function Generator providing continuously variable selection of frequencies from 0.01 Hz to 10 MHz by means of 6 possible range push button combinations and a ÷10 variable symmetry control (which divides any frequency range by 10).

1.2.2 The instrument provides square, sine, and triangle waveforms of levels up to 12 volts peak-to-peak into a matching 50 ohm load and 25 volts peak-to-peak into an open circuit. The positive and negative pulses are unipolar signals at half the amplitude and clamped to ground.

1.2.3 The various waveforms are selected by means of push button switches on the front panel. In addition, by use of the symmetry control, variable waveforms can be generated with duty cycles from 5% - 95%.

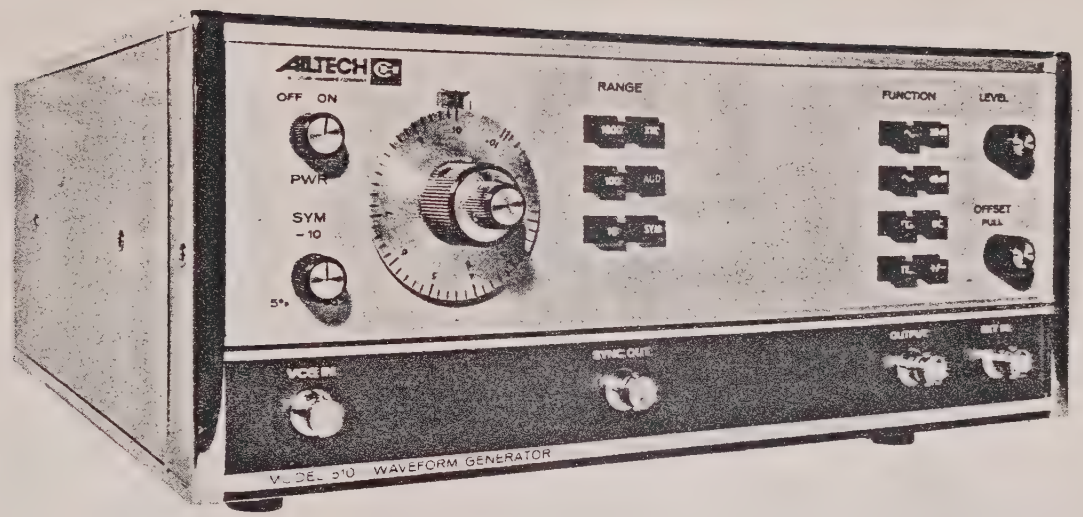
1.2.4 All waveforms can be offset. The entire waveform can be moved about the zero base line by pulling the offset control and varying the potentiometer. In addition by using the DC mode, a ± 10 VDC power source is available.

1.2.5 An external amplifier input is provided on the front panel which enables the instrument to be used as a lab amplifier; or in conjunction with the Function Generator to algebraically add several signals.

1.2.6 The Model 511 (and 521) contains a trigger-gate mode which allows for single or multiple cycle waveform generation. The start stop phase can be adjusted to determine where a cycle is started in relationship to an external trigger input.

1.2.7 An external Voltage-Control-Generator input connector is provided on the front panel, which enables the instrument to generate Frequency Modulated (FM), frequency shift keying (FSK) or "swept" output signals. This is accomplished by applying a sine, square, or sawtooth signal respectively to the VCG in connector.

1.1.8 An audio mode is provided to allow for generating the audio spectrum (20Hz - 20KHz) without requiring range change.



Model 510 VGF 10 MHz Waveform Generator

Model 511 TRIGGER/GATE 10 MHz Waveform Generator

SECTION 2

SPECIFICATIONS, MODEL 511

2.1 WAVEFORMS:

Sine, square, and triangle waveforms selectable at the attenuated output. All outputs are synchronized. Positive or negative pulse, sawtooth, ramp and adjustable DC are also available.

2.2 FREQUENCY:

0.1 Hz - 10 MHz in 6 continuously variable ranges with 1000:1 frequency ratio. Vernier control provided by 6:1 dial gear ratio. Use of symmetry control allows for X10 lower decade. Audio range and control cover 20Hz - 20KHz frequency.

2.3 VOLTAGE:

Variable from 25 vpp into open circuit (12vpp into 50 ohm load) by 0dB, 20dB, 40dB & 60dB attenuation steps with $>$ -20dB vernier ($>$ -80dB range); half amplitude for positive or negative pulses which are clamped to ground.

2.4 VOLTAGE CONTROL GENERATOR (VCG):

$>$ 1000:1 frequency ratio for each range with input of 7.0 VDC or wide band AC up to 500 KHz. Positive or negative input will cause linear increase or decrease, respectively, from set frequency. 10K ohm input impedance (front panel BNC Connector).

2.5 DC OFFSET:

Continuously variable $\pm$10 VDC open circuit or $\pm$5 VDC into 50 ohm load. DC offset plus AC signal cannot exceed maximum voltage output or limiting will occur.

2.6 EXTERNAL AMPLIFIER INPUT:

DC or wideband AC up to 50 MHz with an amplifier gain of 4 into 50 ohm (8 into an open circuit). The amplifier input is 50 ohm and has a maximum input of 5 vpp. The DC offset and fixed attenuators are operative in this mode.

2.7 SYMMETRY:

Waveform symmetry is continuously variable from approximately 5% - 95% (frequency approximately 1/10 dial frequency).

2.8 SYNC OUTPUT:

5vpp into an open circuit; squarewave or pulse synchronized to the main output can be used as a complementary signal to the attenuated output for digital logic testing.

2.9 TRIGGER:

One complete cycle is generated by application of +0.5V signal (20V RMS maximum). Cycle start/stop point variable -90 to +90 (.1Hz to 1MHz) and trigger level and slope adjustable by front panel controls.

2.9.1 External Trig. Input

Front panel BNC connector provided 1K ohm input impedance.

2.9.2 Internal Trig.

Depression of manual push button will cause single cycle to be generated.

2.10 GATE

Application of +0.5V signal (20V RMS maximum) allows continuous oscillation until gate is removed, at which time the last cycle will be completed.

2.10.1 External Gate Input

Front panel BNC connection provided; 1K ohm input impedance.

2.10.2 Internal Gate

Depression of Manual push button will cause continuous oscillation until released.

2.10.3 Output Phase

Cycle start/stop variable from +90 to -90 by front panel control.

2.11 ELECTRICAL

2.11.1 Dial Accuracy:

± 2% of full scale

2.11.2 Frequency Stability:

Short term: ±0.05% of setting for 10 minutes
Long term: ±0.25% of setting for 24 hours

2.11.3 Frequency Response:

Amplitude change of < 0.1dB to 100KHz; 0.5dB to 5MHz; <2dB to 10MHz.

2.11.4 Amplitude Stability:

Short term:	±0.05% of maximum p-p output for 10 minutes
Long term:	±0.25% of maximum p-p output for 24 hours

Note: All stabilities are for constant line voltage and temperature; apply for 10Hz to 1Mhz.

2.11.5 Symmetry (time):

>99% to 1MHz

2.11.6 Sine Wave Distortion:

Below 100KHz, 0.5%; above 100KHz, all harmonics at least down 30 dB.

2.11.7 Square Wave rise and fall times:

Attenuated output:	<10ns (typically 7ns)
Sync output:	< 7ns

2.11.8 Overshoot & Ringing:

<5% of p-p output

2.11.9 Triangle & Ramp Linearity:

>99% to 100KHz
>95% to 5MHz

2.11.10 Operating Temperature:

0° to 50°C

2.11.11 Power:

115VAC ±10% or 230VAC ±10 %, 50 - 400Hz,
30 watts maximum

Note: Except where indicated, specifications apply with frequency controls set between 1.0 and 10.0 on the dial; full output amplitude terminated into 50 ohm; with 25°C ± 5°C ambient after 1 hr. warm-up; all external inputs removed.

2.12 PHYSICAL CHARACTERISTICS:

12 3/4" wide, 5 1/4" high, 13 1/4" deep. Top and bottom covers easily removable exposing all calibration and circuit board areas.

SECTION 3

INSPECTION, INSTALLATION & OPERATION

3.1 INSPECTION & INSTALLATION

3.1.1 General

Your Ailtech Generator is ready for use immediately upon receipt. Make the following checks, however, to assure that no damage has occurred during shipment.

3.1.1.1 Inspect the shipping container prior to acceptance from the carrier. Note any damage to the shipping container on the carrier's receipt.

3.1.1.2 Inspect the instrument for damage. Check for dents, scratches, broken knobs, connectors, etc.

3.1.1.3 Remove the top and bottom covers and inspect for broken components or hardware.

3.1.1.4 If damage is not apparent until after the instrument has been accepted, file a claim for concealed damage with the carrier within 15 days after receipt. All packaging material must be kept for inspection by the carrier's agent. A copy of the claim must be forwarded to Ailtech.

3.1.2 Rack Mounting

3.1.2.1 Ailtech Generators are ready for bench operation as shipped from the factory. If specifically ordered, the necessary parts for rack mounting are packaged with the instrument. To convert to rack installation refer to Figure 3.1 and proceed as follows:

3.1.2.2 Remove the (4) rubber feet and the instrument bail.

3.1.2.3 Remove the Filler Panels from both sides.

3.1.2.4 Install the Rack Mounting Brackets using the #10 screws provided. The instrument is now ready to mount in a standard (19-inch) rack.

3.1.3 Power Requirement

Ailtech instruments may be operated from either 115V or 230V power lines. A switch is provided on the rear panel for quick conversion. For 115V operation the switch must be in the UP position (115 showing).

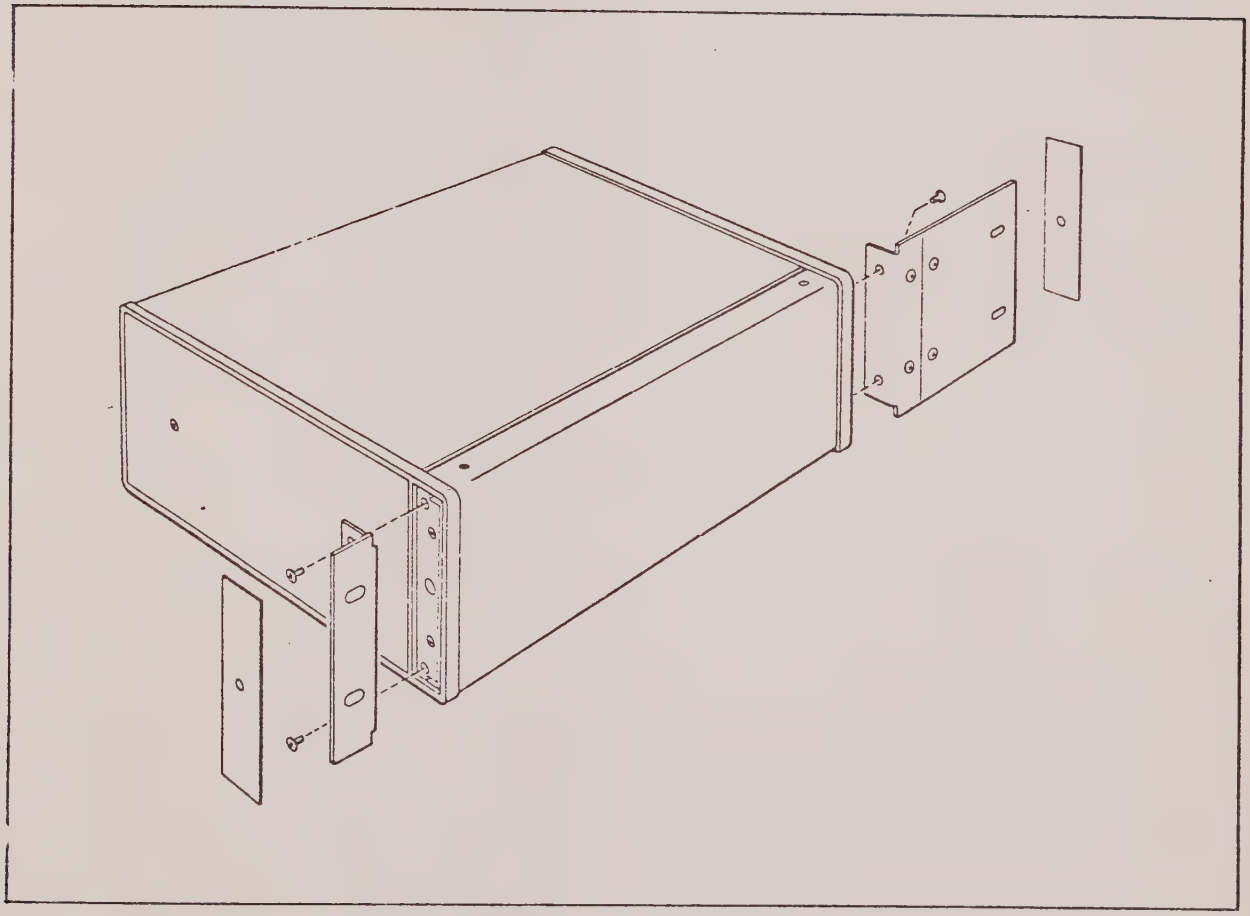


Fig.3.1, Rack Mounting

Note: If the instrument is to be used on a 230V line, make sure the switch is down (230 showing). Also, the line fuse should be changed to an equivalent type, but one-half the current rating.

3.2 OPERATIONAL CONTROLS

3.2.1 The following provides a description of the basic controls used on operating your Series 500 Function Generator. Numbers in parenthesis refer to Fig. 3.2.

(1) POWER SWITCH AND LIGHT: ON-OFF switch and indicator light used to activate the unit.

(2) EXTERNAL VOLTAGE-CONTROL-GENERATOR (VCG) INPUT: Enables the output frequency to be controlled from an outside signal source; thus, provides Frequency Modulation or Frequency Shift output signals.

(3) SYNC OUTPUT: Provides a Sync signal of 5vpp amplitude at same frequency as the output signal when used in all modes except +/- pulse. Then the signal is unipolar; output is either a pulse or squarewave depending on mode of operation.

(4) SYMMETRY CONTROL AND SWITCH: In normal operation when the symmetry switch is depressed the output frequency is divided by 10. The symmetry control allows for adjustment of output duty cycle from 5% - 95%.

(5) FREQUENCY DIAL AND CONTROL: Marked in X1 and X2 ranges to correspond to main dial or audio dial modes. Inner markings refer to audio range of 20Hz-20KHz (other ranges and multipliers disabled in this mode).

(6) RANGE AND RANGE MULTIPLIER SWITCHES: Push button switches which determine the RC networks for the frequency control and timing circuits. X1K is a multiplier to modify X10, X100, X1000 ranges.

(7) AUDIO MODE SWITCH: When depressed the audio mode over-rides any range or multiplier setting except symmetry and allows for the full audio range as set by the frequency dial.

(8) PHASE CONTROL: Determines the start and stop point of the cycle generated when in the triggered mode. Used as with sine and triangle modes to generate sine-squared pulses, ramps and haver-triangle pulses.

(9) TRIGGER INPUT CONNECTOR: Trigger signal applied when in the Triggered & Gated modes to initiate a timing command.

(10) MODE SWITCHES:

(a) Normal. Depressed for normal operation of the generator.

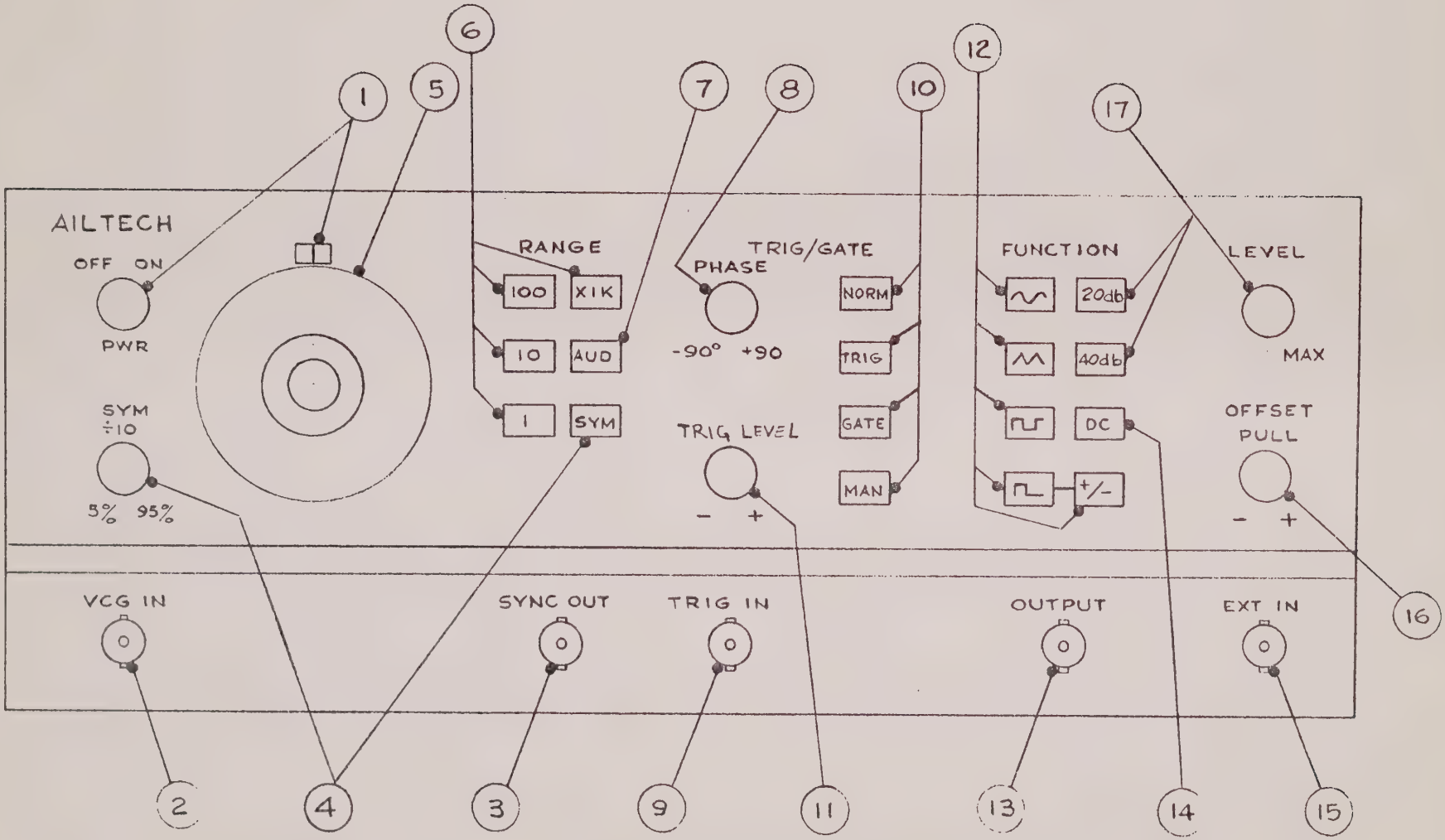


Fig.3.2, Front Panel Controls

(b) Triggered. One complete cycle is generated upon application of a triggered signal.

(c) Gated. Application of a trigger signal allows the generator to operate until trigger signal or gate is removed at which time the last cycle will be completed.

(d) Manual. This switch over-rides either the Triggered or the Gated mode switches. When the Triggered mode is selected, depression of the Manual switch issues a simulated Trigger pulse, and the Generator will run for one complete cycle. If Gated mode is selected, depression of the Manual switch issues a simulated Gate signal, and the Generator will run for as long as the Manual switch is depressed.

(11) TRIGGER LEVEL AND TRIGGER SLOPE CONTROL: Adjusts the sensitivity of the internal trigger amplifier, and enables the trigger amplifier to respond to either a positive or a negative going trigger signal.

(12) FUNCTION SWITCHES: Selects the desired waveform as marked on each push button switch. Sine, triangle and squarewave signals are bipolar waveforms. Pulse waveform is positive-extreme at ground, until +/- button actuated when negative extreme is grounded.

(13) OUTPUT CONNECTOR: Provide output impedance of 50 ohm.

(14) DC MODE SWITCH: When depressed the DC mode disconnects any AC signal generated in the unit but does not affect any DC offset present. This mode can be used in conjunction with the offset control to generate a DC signal. Further, it does not affect an external AC/DC signal applied to the unit via the EXT in connector.

(15) EXTERNAL INPUT CONNECTOR: Accepts the AC/DC signals to be amplified by the Series 500 internal amplifier. Used to algebraically add two signals, one external and one internal, or to be used as a simple DC amplifier.

(16) OFFSET CONTROL: When the offset control is pulled out, the baseline of the selected waveform may be varied about zero level.

(17) ATTENUATOR AND AMPLITUDE CONTROLS: The Amplitude control varies the output over a span of $<$20dB within each range. The attenuation push button provides fixed steps of -20dB, -40dB, or -60dB of signal level reduction.

3.3 OPERATIONAL CHECKOUT:

3.3.1 The operational checkout is a preliminary test and is not intended to confirm performance specifications. (For complete Specification Validation Procedure refer to Section 5).

3.3.2 The only equipment required for the operational checkout is an oscilloscope capable of displaying a waveform of up to 100MHz and a calib. output.

3.3.3 To perform the operational checkout, proceed as follows:

1. Insert the power cord into a 3-wire 115/230 volt, 50-400Hz, single-phase power line outlet.

2. Turn on the Power switch.

3. Observe that the pilot light comes on at this time. (The pilot light is driven from an internal supply).

4. Position the controls as follows:

a.	Function	Sine
b.	Frequency Range	X 1000
c.	Range Multiplier	Out
d.	Frequency Dial	5
e.	Attenuators	Out
f.	Amplitude	Clockwise
g.	Mode	Normal
h.	Offset	In
i.	DC	Out
j.	Sym	Out

5. Connect an oscilloscope to the 50 ohm output connector. (Note: terminate the unit in a 50 ohm load at the input to the scope. This is important, particularly when looking at the square wave at higher frequencies). Observe that the frequency is approximately 5.0 KHz.

6. Vary the Amplitude Control from Min. to Max. Observe that the output level varies correspondingly, as indicated on the oscilloscope. Turn the Amplitude Control to its Max. position.

7. Push the -20dB Attenuator. Observe that the output level drops by a factor of 10. Return the Attenuator to its normal condition.

8. Push the -40dB Attenuator. Observe that the output level drops by a factor of 100.

9. Push the -20dB button and observe that the output level again drops by a factor of 10.

10. Vary the Frequency Dial from .01 to 10. Observe that the frequency increases correspondingly, as indicated on the oscilloscope.

11. Repeat Step 10 for the other Frequency Ranges.

12. Position all controls as in Step 3.

13. Depress the Square, Sine, triangle, pulse and +/- switches. Observe that the output waveform changes accordingly.

14. Depress the Symmetry button. Observe that the frequency is divided by 10 and that the Symmetry control varies the selected waveforms duty cycle from 5% - 95%. Reset the Symmetry button.

15. Depress the Audio button. Observe that the frequency is changed and now covers the audio range as you vary the frequency dial. Reset the Audio button.

16. Connect the oscilloscope to the sync output. Observe that the sync output varies in duty cycle as the symmetry control is changed. note that it changes in amplitude and phase.

17. Position all controls as in Step 3.

18. Pull the offset control "on". Observe that the AC signal varies about ground as the DC offset control is changed.

19. Push the DC mode button. Vary the offset control. Observe that the AC signal is removed and only the DC component remains.

20. Connect the Sync output to the external input connector. Observe that the sync output now is superimposed on the DC offset. This verifies that the generator can be used as a lab amplifier.

21. Reset DC mode button and offset control. Observe with the sync signal tied to the external input that this signal is added to the main generator frequency.

22. Reset all controls as in Step 3.

23. Connect the calibrated output from the oscilloscope (1V) to the trig in connector on front panel.

24. Depress the Trig. push button.

25. Vary the trigger level control until one cycle of output signal is obtained. (It may be necessary to vary the sweep speed of the oscilloscope slightly to adjust the triggering to lock on one cycle.)

26. Vary the Phase control. Observe that the base line of the signal varies from -90° to +90°. This is the variable start-stop control.

27. Depress the Gate push button.

28. Observe that a burst of cycles is generated at the rate of the output from the oscilloscope.

29. Remove Trigger signal from scope. Depress the Man push button.

30. Observe that the generator is running for as long as the Man push button is depressed.

31. Depress the Norm push button.

This completes the Operational Checkout. If the instrument fails during any portion of the operational checkout, notify your local Ailtech representative immediately. The representative will arrange the repair or replacement of your instrument at the earliest possible moment.

SECTION 4

THEORY OF OPERATION

This Section outlines theory of operation of each of the major sub-sections of the Series 500 Function Generator. Referenced schematics are contained in Section 6. Simplified schematics may be found in Section 5.7. A block schematic for the basic instrument immediately follows.

4.1 POWER SUPPLIES

The power supplies of the Series 500 generator are of two types. The highly regulated ±18V "A" supplies which are used as reference for the lesser regulated ±18V "B" and ±8V supplies.

4.1.1 ±18V "A" Supplies

The +18V "A" supply obtains a reference voltage from VR503, a temperature compensated reference diode. The output of the +18V "A" is compared to the reference and the error amplified by IC501. The output of IC501 drives the Darlington pair Q501, 502 in a direction such as to minimize the error signal at its input. R508 sets the output level of the +18V "A" supply by setting the feedback divider ratio. R504 is a load current sensing resistor. The load current produces a voltage drop across this resistor and is sensed by Q503, under normal load currents Q503 is biased off. When the load current increases Q503 turns on which results in turning the Darlington pair off, thus limiting the load current and voltage. The reference for the negative -18V "A" supply is ground, the feedback divider is tied to +18V "A" and the output of the -18V "A" supply. Since the divider is symmetrical the -18V "A" supply tracks the +18V "A" supply.

4.1.2 ±18V "B", ±8V Supplies

The reference for the positive +18V "B" supply is the positive +18V "A" supply output. The Base of Q505 is tied to the reference supply through CR510. The Emitter of Q510 is the output of the +18V "B" supply and tracks the +18V "A" supply because of the matched diode drops. Q505 is the voltage reference of the +18V "B" supply, the current is supplied by Q504 which is driven by the collector of Q505. Resistors R515, 516 sense the supply current to the load. If the voltage drop across these

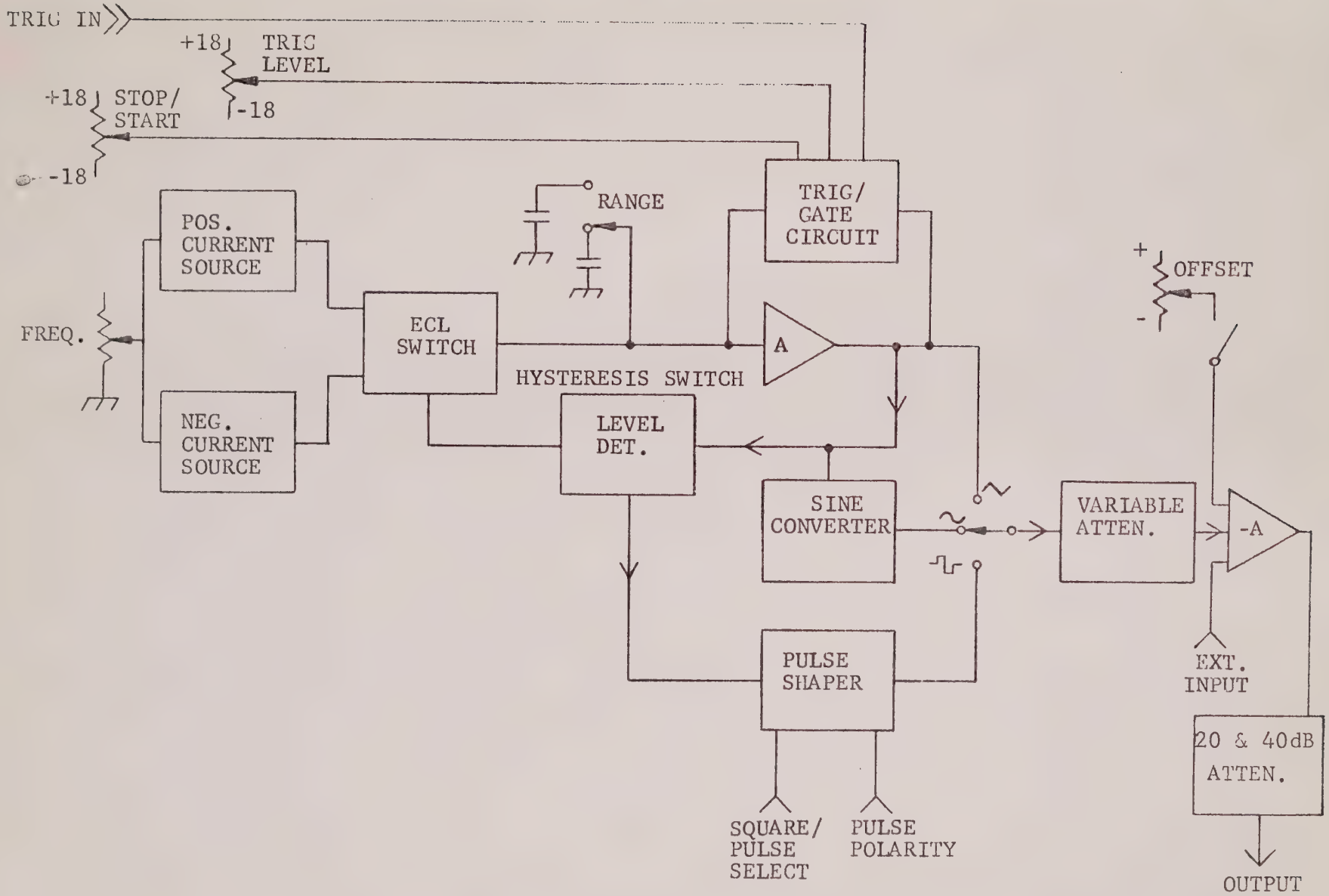


Fig. 4.1 BLOCK SCHEMATIC.

resistors become too large, Q509 will turn on back biasing CR510, thus lowering the output voltage and producing a current limit of the supply. The negative -18V "B" supply receives its reference from the -18V "A" supply and is identical in operation to the positive +18V "B" supply.

The +8V supplies are also identical except that they receive their reference from the resistor divider connected to the +18V "A" supplies. To reduce power consumption, these supplies receive their power from the +18V "B" supplies.

4.2 INTEGRATOR

The heart of the Series 500 Function Generator is the voltage controlled generator (VCG). The generator produces triangle and square waves at a frequency which is determined by the voltage at its input and the selected timing capacitor.

4.2.1 Current Sources

The integrator used in the VCG is a passive type which requires a positive and negative current source. For symmetrical waveforms the current sources must be equal, thus they must track each other at all frequencies. The voltage of the Frequency Dial and the VCG input are summed together by the operational amplifier IC103 which produces a negative voltage output. IC101 tracks the output voltage of IC103, thus producing a positive voltage equal in magnitude to the negative voltage of IC103. IC102 and IC104 are connected as current amplifiers, a voltage applied to the input resistor produces a current through the resistor equal to the output current of the amplifier. The input voltage to IC102 is positive resulting in a positive current and the input to IC104 is a negative voltage resulting in a negative current. To produce unsymmetrical waveforms, the currents are unbalanced by varying the input resistance of the positive current source and oppositely varying the input resistors of the negative current source.

4.2.2 ECL Quad Switch

As a constant positive current is applied to a capacitor the voltage across the capacitor increases linearly with time; conversely, if a negative current is applied the voltage decreases linearly with time. To generate a triangle wave positive and negative currents can be alternately switched to a capacitor; the ECL Quad switch performs this function. Q108, 109, 112, 113 form the ECL switch with Q108, 112 switching the positive current and Q109, 113 switching the negative current. The bases of the ECL switch are biased together such that only two alternate transistors are on at a time. Q108, 109 switch the charging current to the

timing capacitor; Q112, 113 switch the charging current to ground. For example when Q108 is on, supplying positive current to the capacitor, Q113 is also on supplying the negative current from ground.

Q107 and Q114 from another ECL switch used to generate complementary pulses to drive the pulse shaping circuit of the sine/pulse board.

4.2.3 Hysteresis Switch

The hysteresis switch produces a pulse output when the voltage across the timing capacitor reaches +3 volts in the positive direction or -3 volts in the negative direction. This pulse is applied to the ECL Quad switch to switch the positive or negative charging current, thus producing a feedback loop for the oscillator.

The Hysteresis switch is also an ECL switch in which only one transistor is on at a time (Q118, 119 form the switch). If the triangle is charging to the positive voltage, Q119 is on and Q118 is off. As +3v is approached, Q119 begins turning off and Q118 begins turning on, the collector of Q118 ties to the input summing junction. The result is a positive feedback which sharply increases the rate of turn off of Q119. The collector of Q119 drives the ECL Quad Switch.

4.2.4 Triangle Amplifier

The charging currents at low frequencies becomes very small (20na) thus a buffer is needed to prevent loading of the charging current. Q110 and Q111 form a very high input impedance source follower and current source. The output of the source follower drives the Hysteresis switch directly minimizing loop delays, it also drives the triangle amplifier. The triangle amplifier is a noninverting unity gain amplifier which has a high input impedance and a 50 ohm output impedance to drive the other circuits.

4.3 SINE SHAPER/PULSE CIRCUITS

This board consists of a sine shaping circuit, a sine amplifier, a pulse shaping circuit and mode selection switches.

4.3.1 Sine Shaper

The sine shaping network operates on the triangle wave to produce a sine wave output. The diodes of IC 302 conduct during the positive half cycle of the triangle wave and the diodes of IC 301 conduct during the negative half cycle. The break points are controlled by the positive voltage

regulator Q305, 306 and the negative regulator Q301, 302. The resistor strings provide the diode break voltage supply producing smooth break points for the sine wave.

4.3.2 Sine Amplifier

The sine wave produced by the sine shaping circuit is a sine wave inscribed within the triangle wave. The sine amplifier amplifies the sine wave to an amplitude equal that of the input triangle wave and also provides a 50 ohm output to the output amplifier. The sine amp is a non-inverting amplifier with a complementary emitter follower output stage.

4.3.3 Pulse Shaper

The pulse shaper circuit provides a fast bipolar, positive or negative pulse to the output amplifier and to the sync output. The complementary pulses from the integrator are reshaped by the current switch Q314, 323. This output is a positive pulse which drives the Quad current switch Q315, Q322. When in the squarewave mode the output from the Quad switch is a bipolar pulse. When positive pulse is selected the current to the positive Quad switch is removed and the output is a negative going pulse, which is amplified by a gain of -4 in the output amp producing a positive pulse. When the +/- switch is in the out position the current to the negative Quad switch is removed and a positive output from the switch is produced. Since the sync output is taken from the opposite collector of the Quad switch the sync output is in phase with the main output.

4.4 OUTPUT AMPLIFIER

The output amplifier is a linear operational amplifier with a voltage gain of -4. The input and output impedances of the amplifier are approximately 50 ohm and must be driven from a 50 ohm source and into a 50 ohm load for best pulse fidelity.

4.4.1 Theory of Operation

A complete schematic of the output amplifier can be found in Section 6. The mode of operation (Sine, triangle, square, pulse) is selected by the switches on the sine/pulse board. The signal is then attenuated by the 50 ohm level control on the front panel and sent into the summing junction input of the amplifier. The summing junction of an operational amplifier is very low impedance and therefore is a current summing junction which sums the input signal, offset, Ext input and feedback currents. The feedback current is supplied from the power output stage which is a

complementary emitter follower (CEF) driver. When the output is at 0 volts both Q413 and Q405 are on, the feedback current and load current is 0 ma thus the collector current of Q413 equals the collector current of Q405. The collector currents are limited by R433 and R416; as current increases, a larger voltage drop is produced across the resistors which decreases the Base Emitter voltage thus decreasing the current. The Base voltages are fixed by CR401 and CR402. When a positive input current is applied, the feedback current must be negative to balance the summing junction. The negative current flowing through the feedback resistor produces a negative voltage at the output. The negative load current and feedback current is supplied by Q405. Since no positive current is needed Q413 is off. When a negative input current is applied Q413 turns on supplying a positive feedback current with the resulting positive output voltage, and Q405 turns off.

The drivers for the CEF are the common base stages Q412 and Q404. The current through Q412 equals the current through Q404 in a steady state condition. During transition of the output the currents are greatly unbalanced because of the modulation of the current amplifiers Q410, 411 and Q402, 403 by the transition of the input current. The common base stage currents are balanced by measuring the voltage drops across the emitter resistor of the current amps and adjusting the voltage regulators such that the voltage drops are equal. The current sources Q409 and Q401 supply the zener current for VR401 and VR 403 which supply the bias voltage for the current amps.

4.5 TRIG/GATE BOARD

The Trigger/Gate circuit consists of a lock up amplifier and a logic circuit. The lock up amplifier prevents the integrator circuit from functioning by providing an alternate current source to the integrator capacitor in the triggered mode, after an input signal, the logic circuit turns the lock up amplifier off for one cycle of the integrator. In the Gate mode, the logic circuit turns the lock amplifier off until the gate signal is removed. If the gate signal is removed during a cycle, the lock up amplifier will stay off until the end of that cycle.

4.5.1 Trigger Mode

Referring to the simplified schematic and the timing diagram: when an input trigger signal crosses the threshold level (set by the front panel level control) the Schmitt trigger output rises. The positive going edge of this output causes the Flip-Flop output to change to a low state, which changes the "or" gate output to a low state, and turns the lock up amplifier off. The integrator capacitor now charges in a negative direction. When the voltage across the integrator capacitor reaches -3v, the ECL switch in the integrator circuit changes state. The "n" output

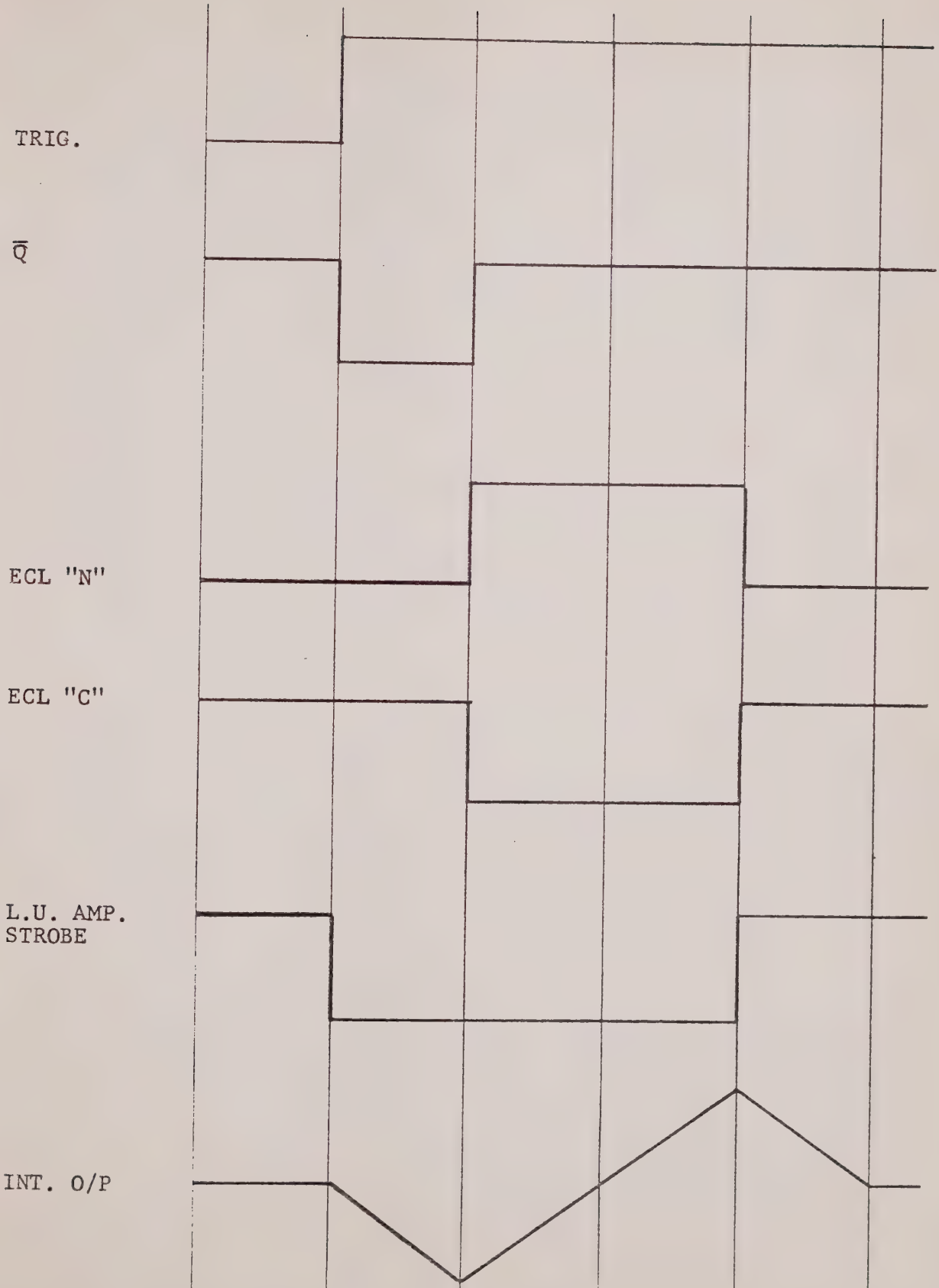


Fig. 4.2 TRIG. MODE TIMING DIAGRAM.

of the ECL switch is used to reset the Flip-Flop in the trigger circuit. The "c" output of the ECL switch is connected to the "or" gate in the trigger circuit, so the output of the "or" gate stays low, holding the lock up amplifier off. The integrator capacitor now charges in a positive direction, until the voltage across it reaches +3v. At this point the ECL switch again changes state, both inputs to the "or" gate are now high, so the "or" gate output switches to a high state. This would enable the lock up amplifier to supply current to the integrating capacitor except that the lock up amplifier has a differential input, and therefore the capacitor will continue to discharge until the voltage across it is the same as the voltage set by the front panel start/stop control. At this point the lock up amplifier supplies current to maintain the charge on the capacitor at a constant level.

4.5.2 Gate Mode

In Gate Mode, the Flip-Flop "clock" input is connected to the ECL "n" output, and the "set" input is connected to the output of the Schmitt trigger. The "set" input of the Flip-Flop overrides the clock input, so when a gate signal is applied the "$\overline{Q}$" output stays low until the gate signal is removed. On the next transition of the ECL "n" output, after the gate signal is removed, the "$\overline{Q}$" output goes high. When the ECL "c" output goes high, the "or" gate enables the lock up amplifier to turn on at the start/stop level.

Referring to the detailed schematic, Q2 through Q6 form the Schmitt trigger circuit. IC 1 is the Flip-Flop, Q7 through Q11 form the "or" gate. The lock up amplifier consists of Q14 through Q17, Q19 through Q21. Q13 sets the center point of the start/stop control. Q12 keeps the start/stop level constant for all settings of the frequency dial. Relay K601 is normally open, K602 is normally closed. When the 10MHz range is selected, K601 closes, and R33 corrects the start/stop level; K602 opens, and changes the gain of the lock up amplifier. Q21 is a voltage regulator, and supplies +5v to the IC.

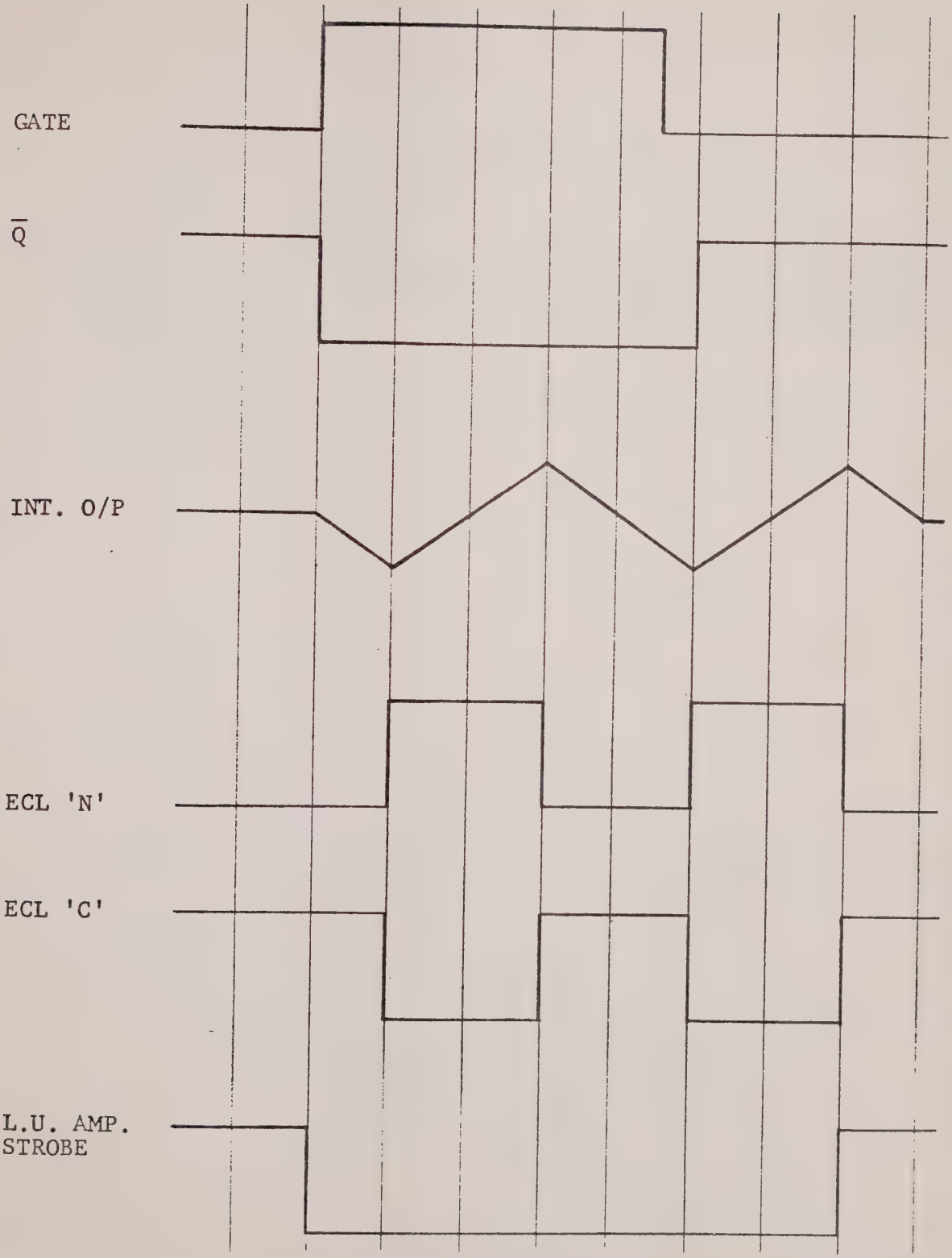


Fig. 4.3 GATE MODE TIMING DIAGRAM.

SECTION 5

CALIBRATION PROCEDURE

Sections 5.1, 5.2, 5.3, 5.4, and 5.5 provide instructions for setting up the basic instrument. A recommended final data sheet is given in Section 5.6. Section 5.7 contains detail relating to individual modules which comprise the basic unit should detailed diagnosis/study become necessary.

Prior to calibrating the unit, turn it on and allow it to stabilize for at least one hour. Suggested control settings for the stabilization period are as follows:

Frequency	-	10 MHz
Trig. Switch	-	Norm
Waveform	-	Square
Level	-	Clockwise
Attenuator	-	20 DB Depressed

5.1 POWER SUPPLIES

5.1.1 Using a digital voltmeter, check the +18V "A" supply at R504. Adjust to +18.0v with R508.

5.1.2 Verify that the -18V "A" and +18V "B" are 18V +.25V.

5.1.3 Check the +8V supplies. Typical voltage is 8.3V.

5.1.4 Check the unregulated supplies. Typical voltage is +36V.

5.2 OUTPUT AMPLIFIER

5.2.1 Control settings:

Power	-	Off
Attenuator	-	0 DB
Level	-	Fully Clockwise
Waveform	-	D.C.
Offset	-	Off

5.2.2 Using a short clip lead, short the input summing junction to ground.

5.2.3 Turn power on, check the voltage across R427 and R428. Adjust to ~~1.75~~ 1.55V with R431. Check the voltage across R410 and R411. Adjust to ~~1.75~~ 1.55V with R414.

5.2.4 Remove the clip lead, and connect the DVM to the output connector. Adjust the output voltage to zero with R402.

5.2.5 Connect the output to a sampling oscilloscope with an input impedance of 50 ohm. Select 10MHz square wave, adjust the output level to about 10V peak to peak. Adjust C416 for less than 10nS rise time, with less than 5% overshoot.

5.3 INTEGRATOR

5.3.1 Control settings:

Power	-	Off
Dial	-	10
Range	-	10 Depressed
1K	-	Depressed
Aud.	-	Out
Sym.	-	Out
Trig.	-	Norm
Waveform	-	Triangle
Attenuator	-	0 DB
Level	-	Fully Clockwise
DC	-	Out

5.3.2 Using a short clip lead, short the stop/start terminal (located under C103) to ground. Connect an oscilloscope to the output, terminate the cable into 50 ohm at the scope. Set the scope to D.C.

5.3.3 Turn power on, adjust R139 for zero volts out.

5.3.4 Remove the clip lead. Adjust R147 for a triangle peak amplitude of -6V adjust R152 for a peak amplitude of +6V.

5.3.5 Set the frequency dial to 1. Adjust R119 to obtain a symmetrical waveform.

5.3.6 Set the dial to 10, connect a frequency counter to the sync. output connector, and adjust R101 for a period of 10 µs. (100 KHz).

5.3.7 Set the dial to 1, adjust R106 for a period of 100 uS (10 KHz).

5.3.8 Set the dial to .01. Adjust R105 for a period of 10mS (100 Hz), adjusting R119 as necessary to maintain a symmetrical waveform.

5.3.9 Repeat steps 3.6, 3.7 and 3.8 until the dial calibration is within specifications.

5.3.10 Set the dial to 10. Depress the 1000 button. Adjust C115 for 6V peak amplitude. Adjust C103 for an output frequency of 10 MHz.

5.4 SINE/PULSE BOARD

5.4.1 Control settings:

Dial	-	10
Range	-	1000 Depressed
IK	-	Out
Aud.	-	Out
Sym.	-	Out
Trig.	-	Norm
Waveform	-	Square
Attenuator	-	0 DB
Level	-	Fully Clockwise

5.4.2 Connect an oscilloscope to the output, terminate the cable into 50 ohm at the scope. Set the scope to D.C.

5.4.3 Adjust R363 for -6V peak amplitude. Adjust R367 for +6V peak amplitude.

5.4.4 Select sine wave. Adjust R342 for zero offset. Adjust R345 for a 12V peak to peak sine wave.

5.4.5 Adjust R303, 312, 321 and 332 for the best looking sine wave. Readjust R342 and 345 as necessary, then connect the output to a distortion analyzer. Adjust R303, 312, 321, and 332 for minimum distortion. Re-check amplitude and offset.

5.5 TRIGGER BOARD

5.5.1 Control settings:

Dial	-	5
Range	-	10 Depressed
IK	-	Depressed
Aud.	-	Out
Sym.	-	Out
Trig.	-	Depressed
Waveform	-	Sine

5.5.2 Connect a 5 KHz 1V Rms trigger source totthe trig. input connector. Connect the output to an oscilloscope, terminate the cable into 50 ohm at the scope. Adjust the trig. level control to obtain a triggered waveform display. Set the scope to D.C.

5.5.3 Center the front panel phase control. Vary the frequency dial between 1 and 10. Adjust R654 so that the base line of the output waveform does not vary when the dial is varied between 1 and 10.

5.5.4 Depress the 1000 switch. Adjust R652 so that the base line is constant for dial settings between 1 and 10.

5.6 FINAL CHECKOUT

The following data should be obtained and compared to original/spec data to confirm proper operation.

5.6.1 Output Amplitude (10 KHz)

Triangle	_____	check
Square	_____	"
Sine	_____	"
Pulse +	_____	"
Pulse -	_____	"

5.6.2 Dial Accuracy

Dial	Range	X1K		
10	10	out	_____	check
10	100	out	_____	"
10	1000	out	_____	"
10	1000	in	_____	"
10	100	in	_____	"
10	10	in	_____	"
1	10	in	_____	"
1	100	in	_____	"
1	1000	in	_____	"
1	1000	out	_____	"
1	100	out	_____	"
1	10	out	_____	"
20	Aud		_____	"
20 KHz	Aud		_____	"

5.6.3 Sine Distortion

100 Hz	_____	Check
1 KHz	_____	"
10 KHz	_____	"
100 KHz	_____	"
1 MHz	_____	"
10 MHz	_____	"

5.6.4

Symmetry	_____	Check
Trig. Phase	_____	"
Gate level	_____	"
Man. Trig.	_____	"
Offset	_____	"
V.G.G. In	_____	"
Ext. In	_____	"
Sync Out	_____	"

5.7 PRETESTS

The following Sections detail the procedures to check individual modular portions of the function generator. Simplified schematics and other data are provided to aid in diagnosis and circuit understanding.

5.7.1 Power Supply Pretest

1. Turn power on. Connect a DVM to R504. Adjust R508 to +18.0 V.

2. The -18V "A" supply, the ±18V "B" supplies, and the ±8V supplies are all referenced to the +18V "A" supply, so no adjustment is possible. Check that the 18V supplies are within ±.25V of the nominal. The ±8V supplies typically measure 8.3V.

Check the unregulated supplies at C501 and C511. Typical voltage, unloaded, is 45-50V.

5.7.2 Integrator, Pretest

1. Depress "10" and "1K" buttons. Release "Aud" and "Sym" buttons. Set the frequency dial to 10. Attach a short clip lead from the stop/start terminal (located under C103) to ground. Attach a scope probe between T.P.1. and ground. Set the scope to D.C.

2. Turn the unit on, and adjust R139 for zero volts at T.P.1.

3. Remove the clip lead, and adjust R152 and 147 until a triangle wave appears at T.P.1. Adjust R147 to obtain a positive peak voltage of +3V. Adjust R152 for a negative peak of -3V.

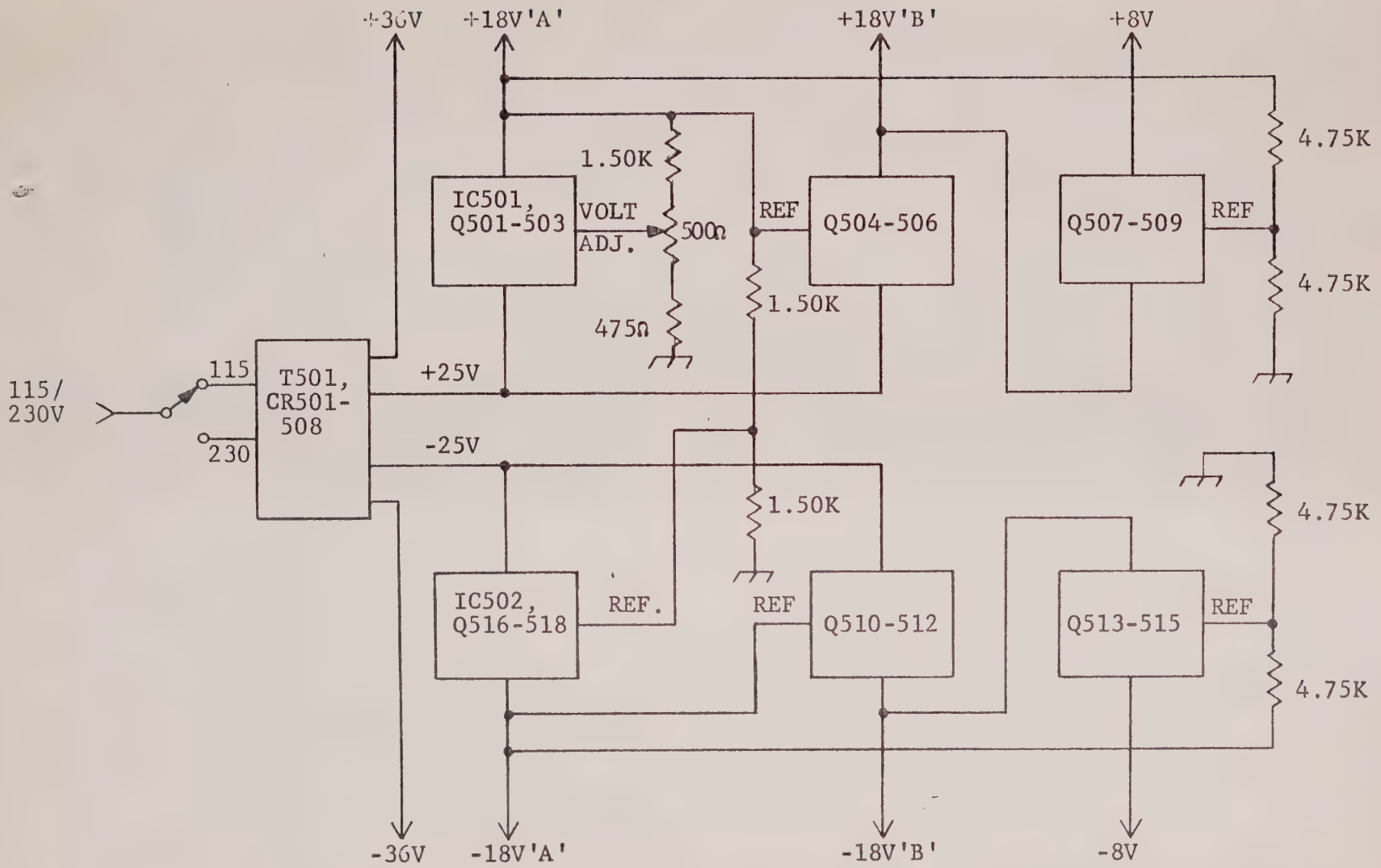


Fig. 5.1 POWER SUPPLY. SIMPLIFIED SCHEMATIC.

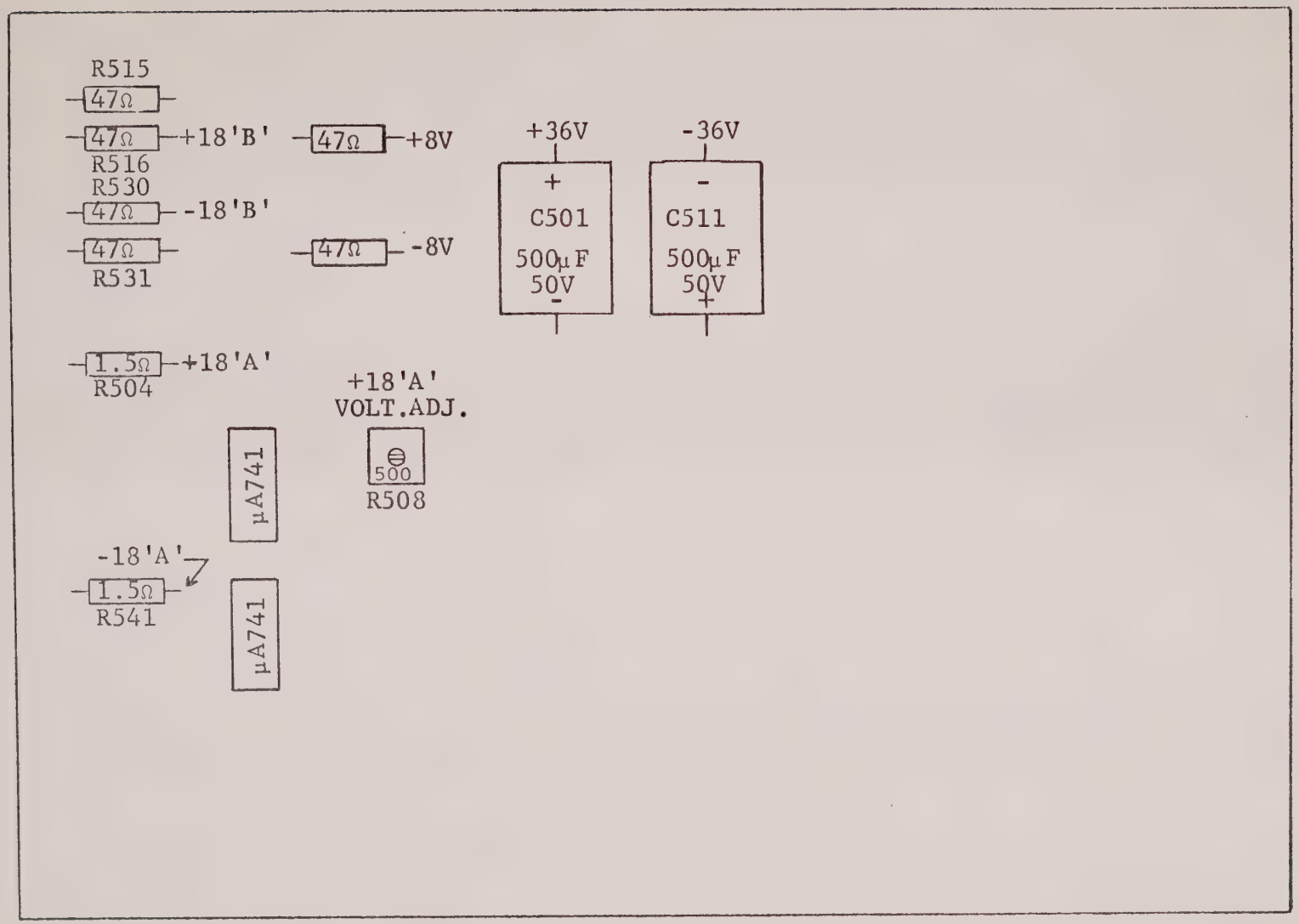


Fig. 5.2 MASTER BOARD. VOLTAGE CHECK POINTS.

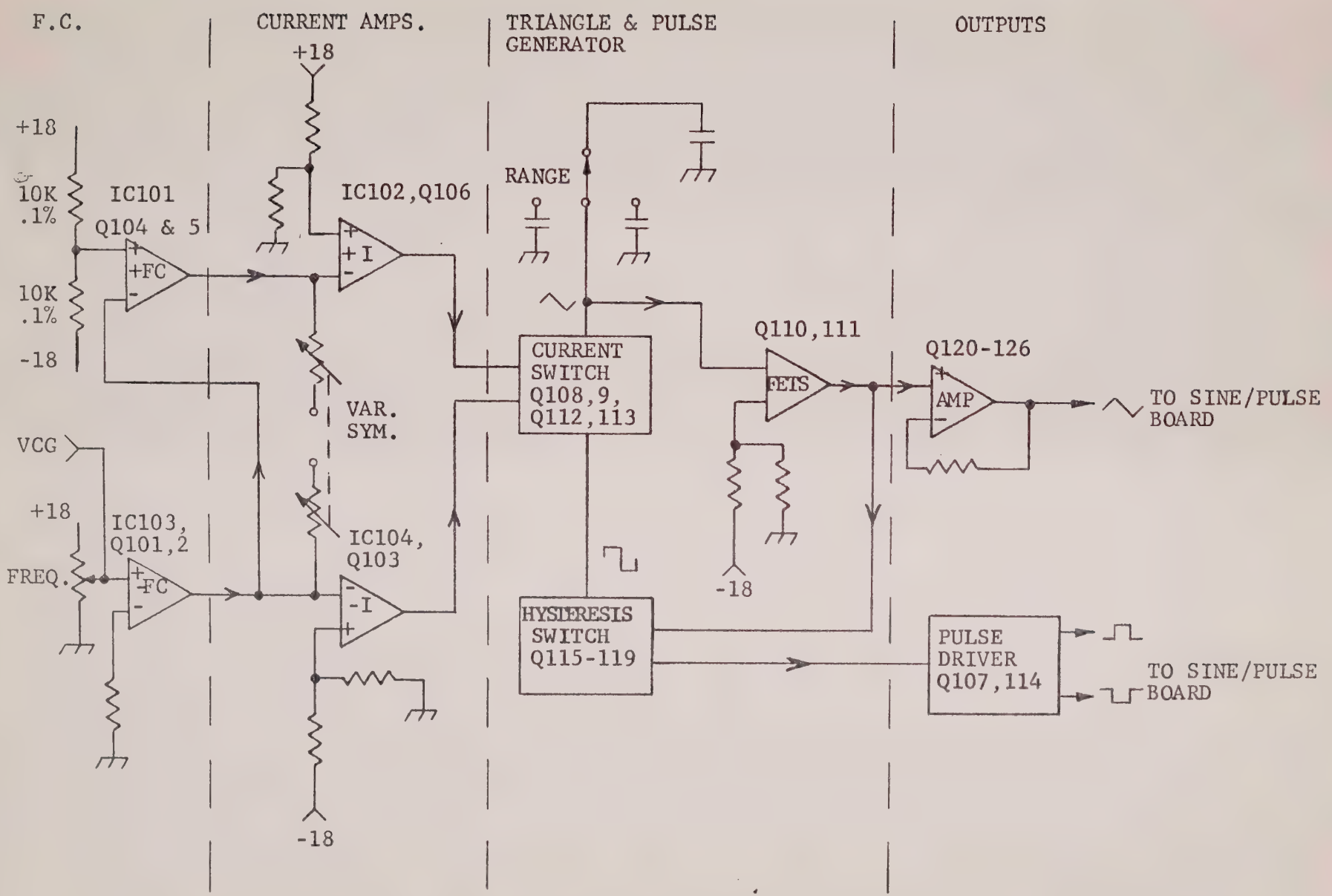


Fig. 5.3 INTEGRATOR. SIMPLIFIED SCHEMATIC.

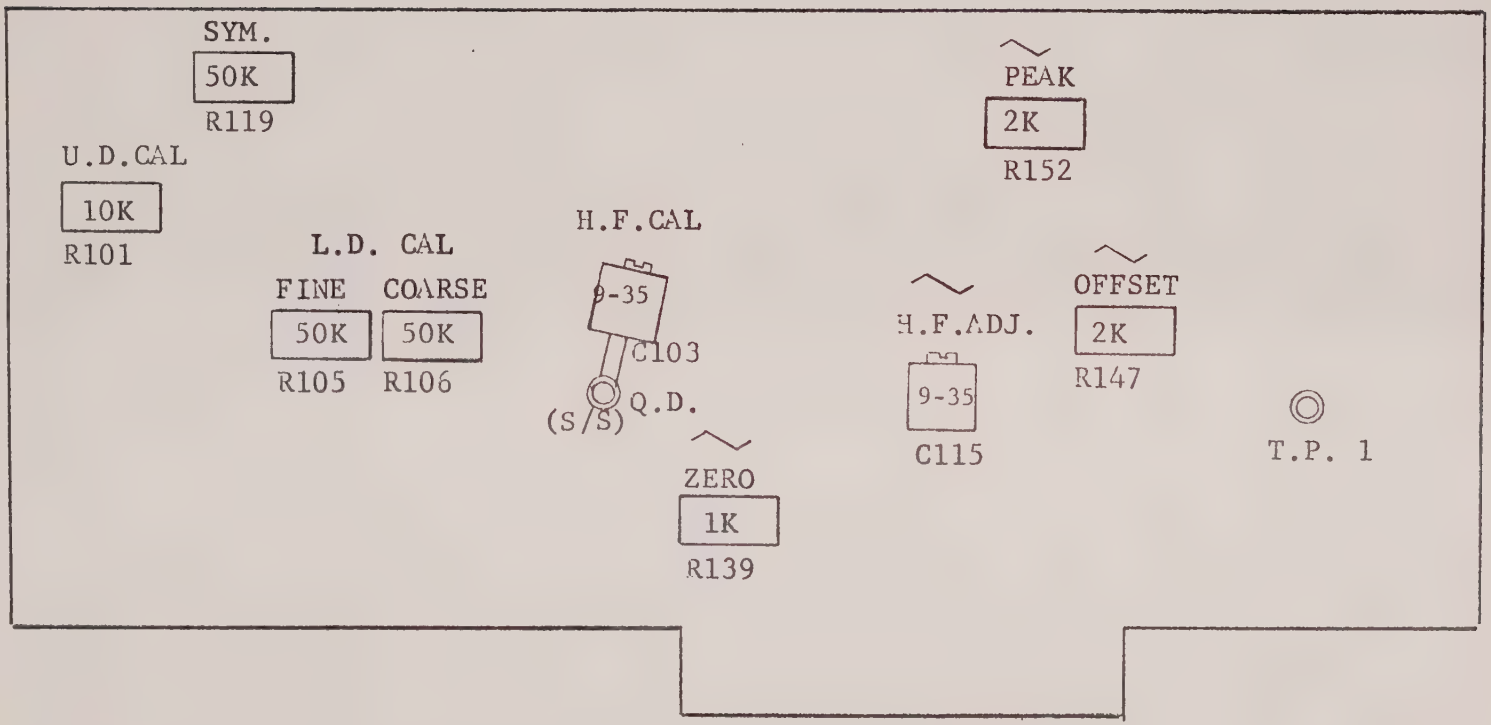


Fig. 5.4 INTEGRATOR TRIMMER LOCATION.

4. Set the Freq. dial to 1. Adjust R119 to obtain a symmetrical waveform.

5. Set the Freq. dial to 10, adjust R101 for a period of 10 µS (100 KHz). Set the Freq. dial to 1, adjust R106 for a period of 100 µS (10 KHz). Set the Freq. dial to .01. Adjust for a period of 10 nS (100 Hz), adjusting R119 as necessary to maintain a symmetrical waveform. Re-check the upper dial calibration, readjust R101 if necessary.

6. Depress the "1000" button. Set the Freq. dial to 10. Adjust the triangle amplitude to 3V peak with C115. Adjust the period to .1µS (10 MHz) with C103.

7. Depress the "100" button. Set the dial to 10. Test select C110 to obtain 1 MHz output.

5.7.3 Sine/Pulse, Pretest

1. Connect a scope probe to the output quick disconnect terminal. Turn the variable attenuator fully counter clockwise. Depress the square wave button. Set the frequency to 10 KHz.

2. Turn the unit on, adjust R363 for +3V peak square wave amplitude. Adjust R367 for -3V peak square wave amplitude.

3. Select sine wave. Adjust R342 to cancel any voltage offset. Adjust R345 to obtain a 3V peak to peak waveform. Adjust R303, 312, 321, and 332 for the best looking sine wave. Readjust R342 and 345 as necessary.

5.7.4 Output Amp Pretest Procedure

1. Using a short clip lead, short the input summing junction to ground.

2. Adjust R431 for a 1.75 drop across R427 and R428. Adjust R414 for a 1.75 drop across R410 and R411.

3. Remove the clip lead. Select D.C. on the waveform switch. Check that the 20DB and 40DB switches are in the 0 DB (OUT) position. Check that the offset switch is in the off (IN) position. Connect a DVM to the output connector. Adjust R402 for zero volts out.

4. Set the Freq. to 10 MHz, connect the output to a sampling scope with a 50 ohm input impedance. Select square wave on the waveform switch. Adjust C403 for a rise time of less than 10 nS, with minimum overshoot.

5. Connect the output to an A.C. voltmeter. Select sine wave, 1 KHz. Terminate the output at the voltmeter with a 50 ohm load. Adjust the output voltage to a convenient reference level. Depress the 20 DB attenuator switch. Check that the output voltage drops by 20 DB ± 1 DB.

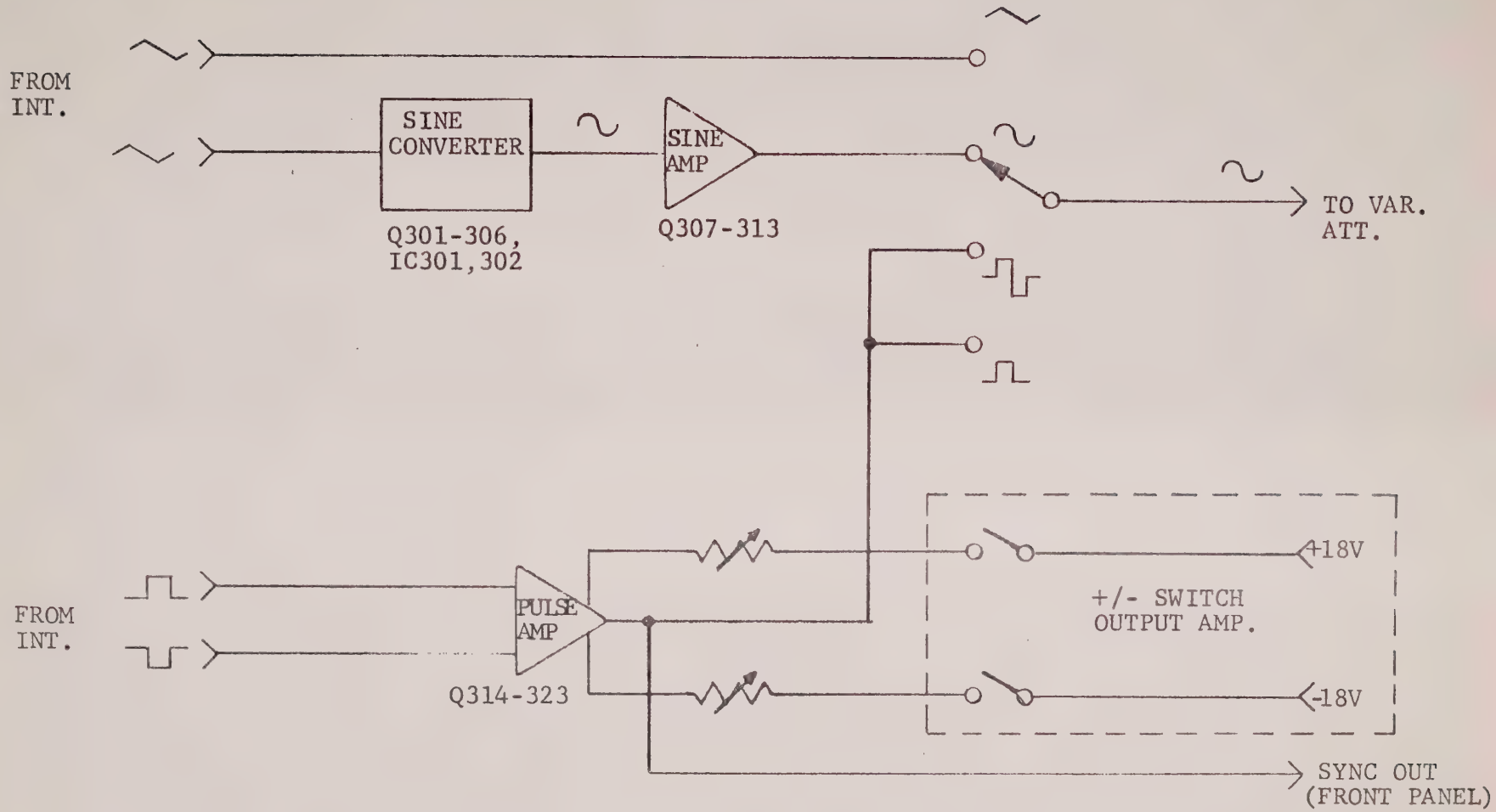


Fig. 5.5 SINE/PULSE SIMPLIFIED SCHEMATIC.

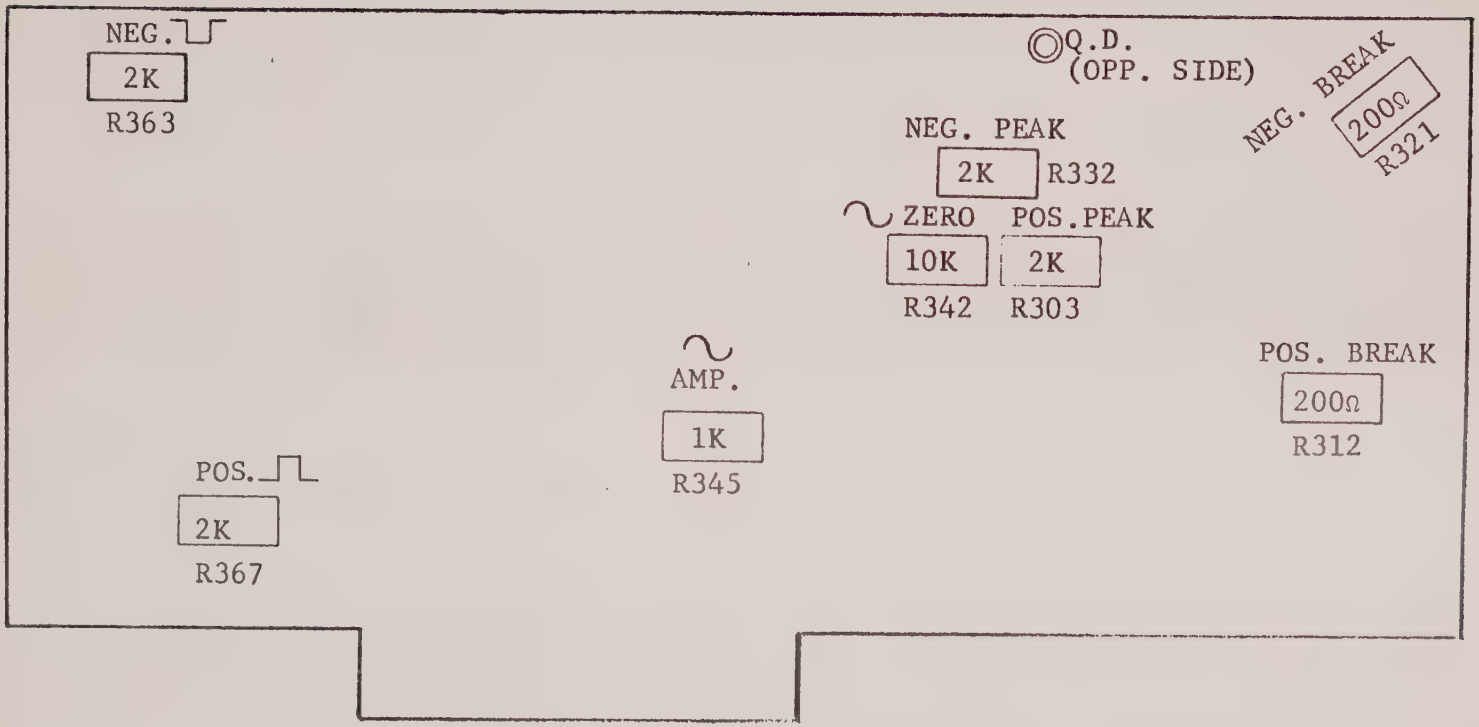


Fig. 5.6 SINE/PULSE. TRIMMER LOCATION.

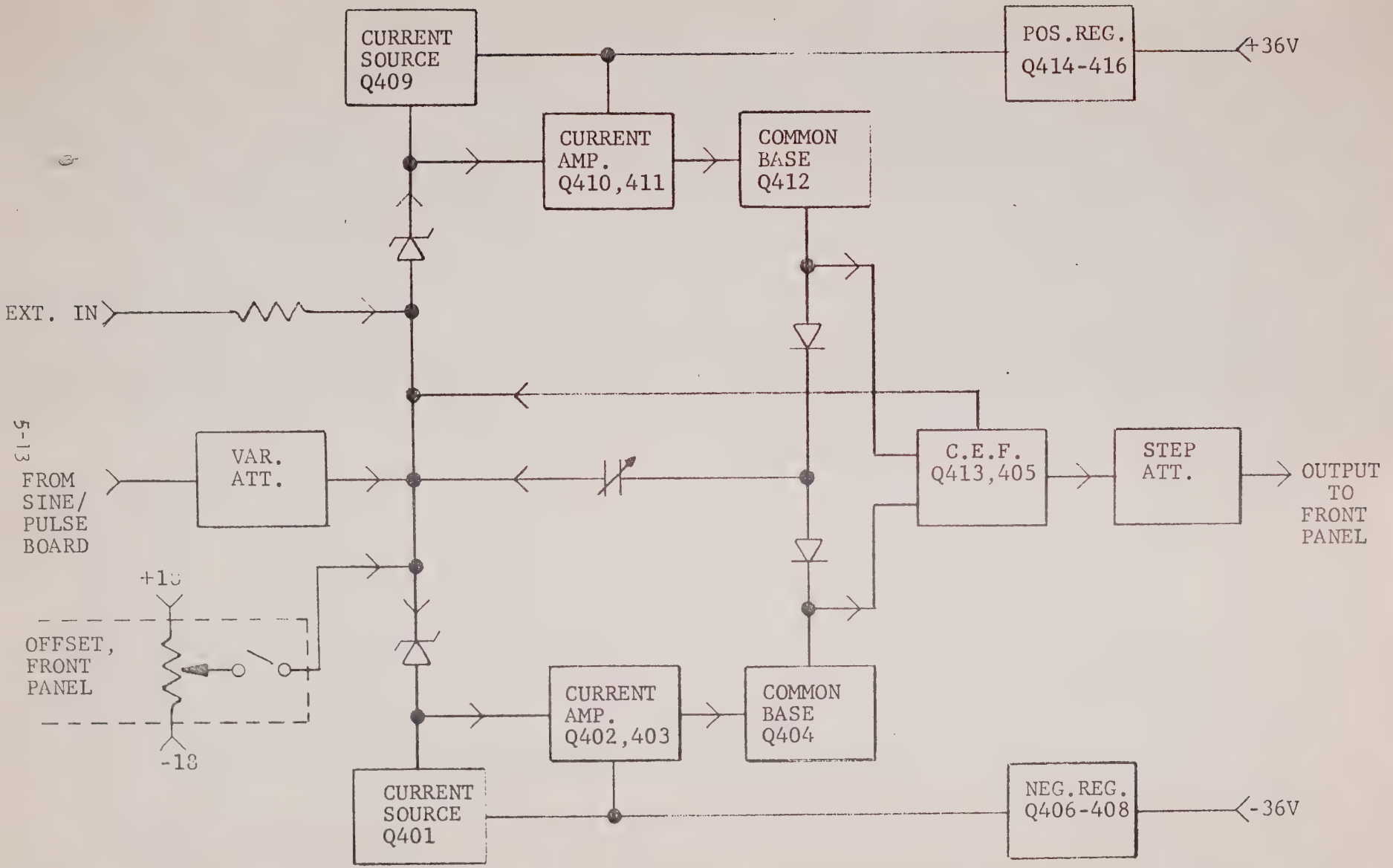


Fig. 5.7 OUTPUT SIMPLIFIED SCHEMATIC.

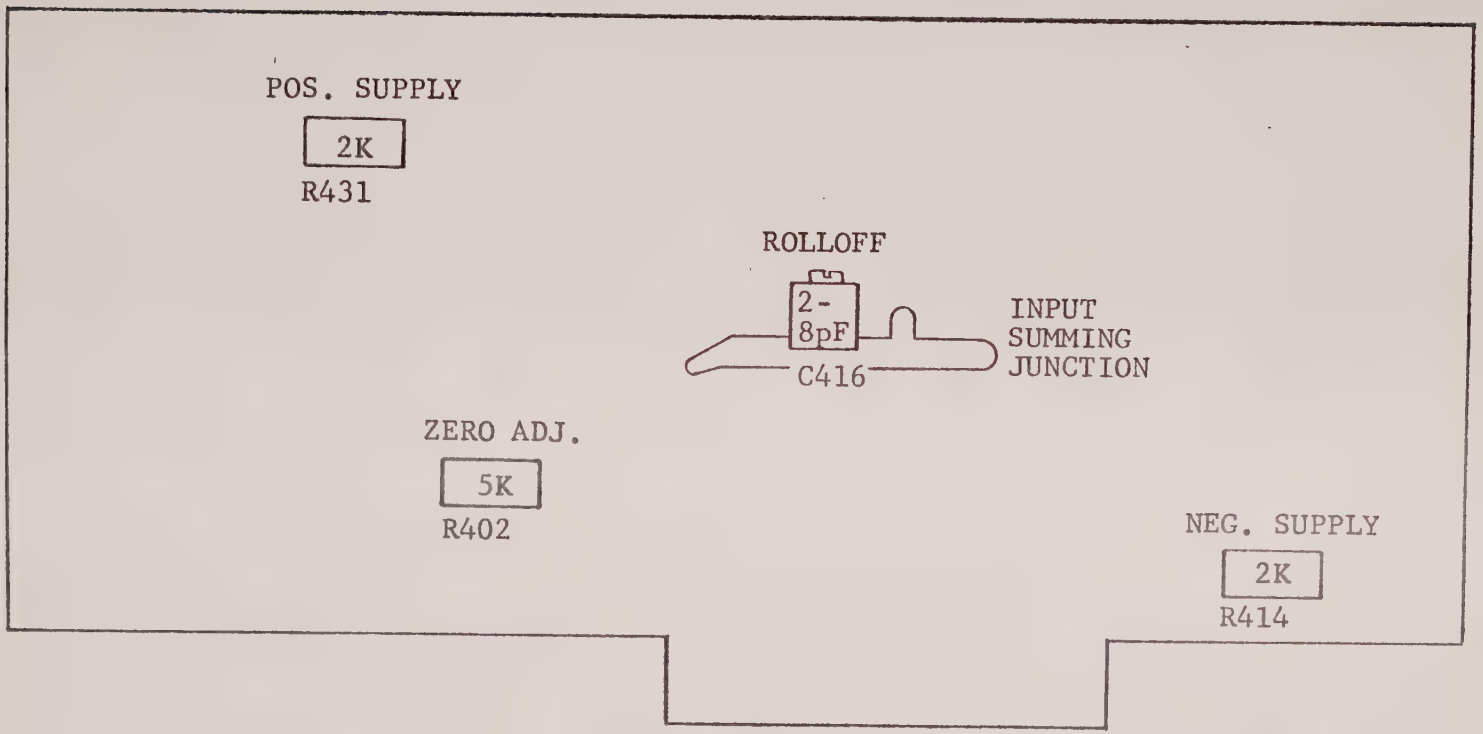


Fig. 5.8 OUTPUT AMP. TRIMMER LOCATION.

Depress the 30 DB switch, release the 20 DB switch, and check that the output is -30 DB + 1 DB.

5.7.5 Trig. Board Pretest Procedure

1. Adjust the output frequency to 5 KHz, select trigger mode, and connect a 1 KHz 1V P-P signal to the trigger input connector. Set the start/stop control to "MID" position.

2. Terminate the output connector with a 50 ohm load at the input to an oscilloscope. Adjust the level control to obtain a triggered waveform on the oscilloscope. Vary the Freq. dial from 1 to 10, adjust R654 so that the base line stays at ground level.

3. Set the output frequency to 5 MHz, change the trigger input frequency to 1 MHz. Adjust R652 so that the base line stays at ground level as the Freq. dial is varied from 1 to 10.

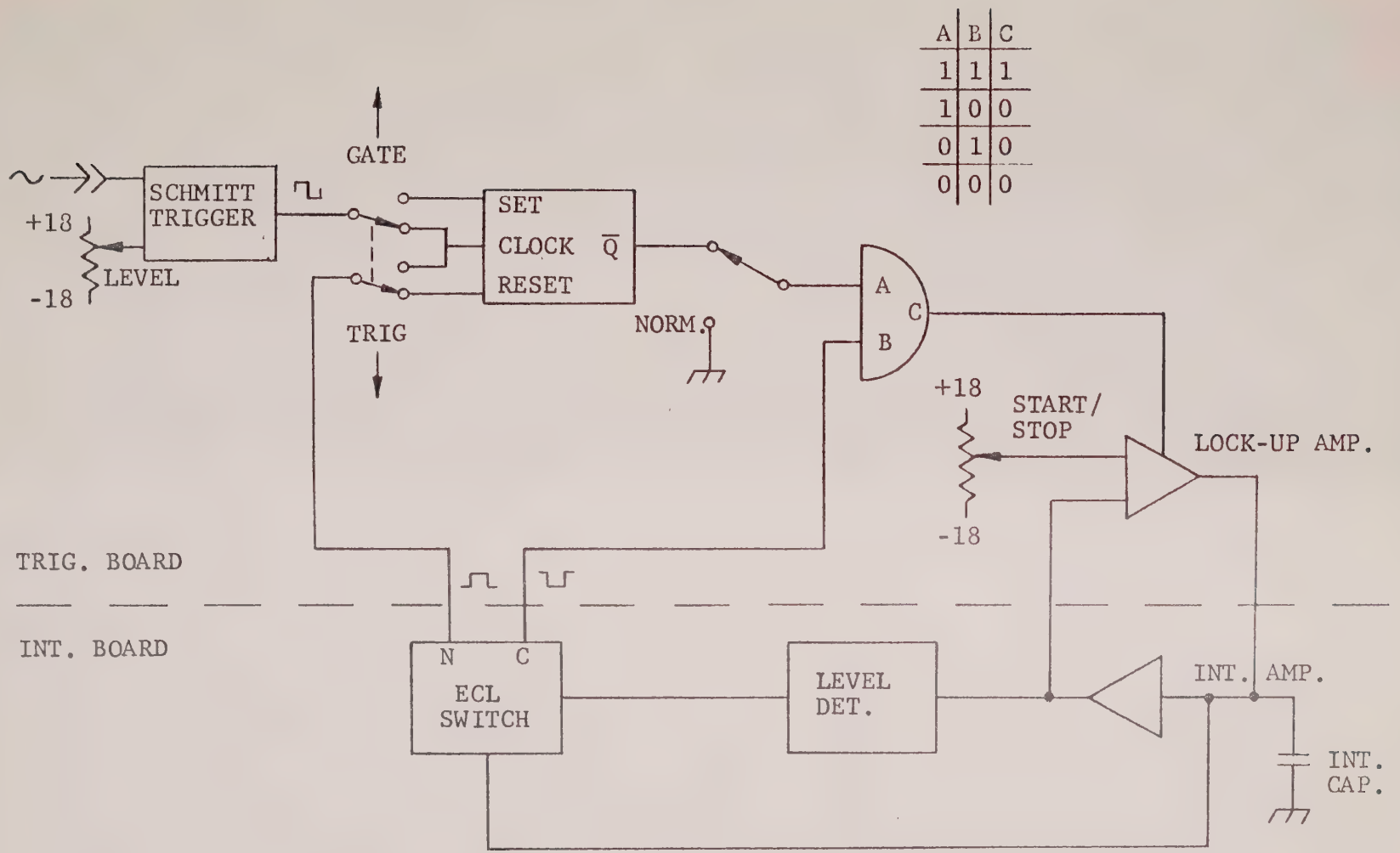
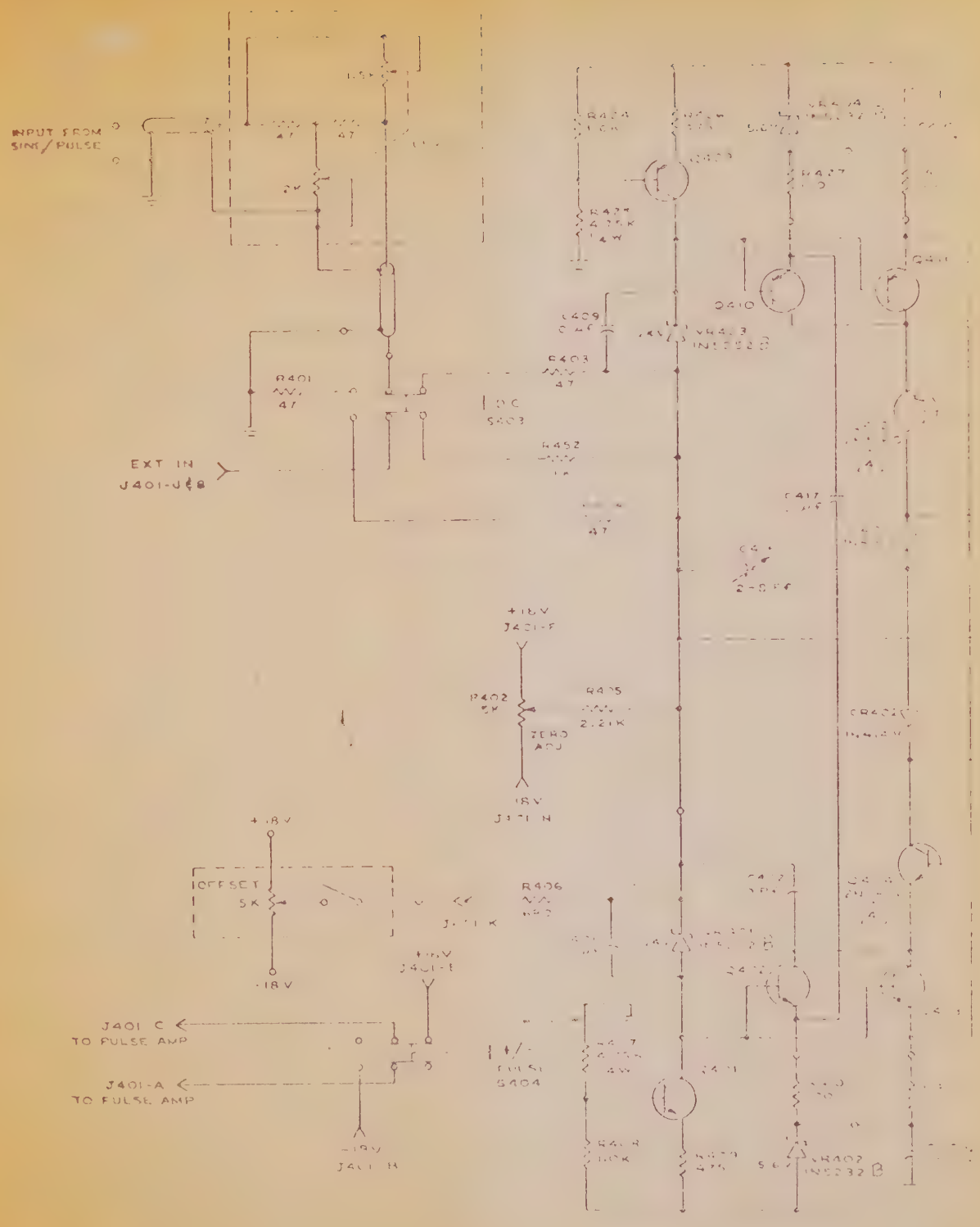


Fig. 5.9 TRIG. CIRCUIT, BLOCK DIAGRAM.

SECTION 6

SCHEMATICS

Schematics are provided in this section which detail circuitry for each module contained in the Function Generator. Reference should be made to Section 4, Theory of Operation, and to the text and Figures of Section 5.7, Pretests.



3 UNMARKED TRANSISTORS:
PNP, MPS6510
NPN, MPS6515

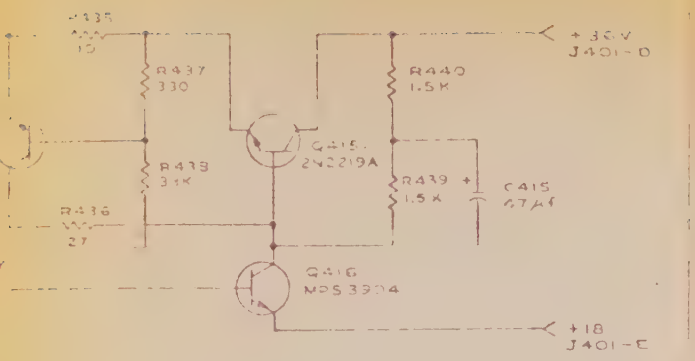
2 ALL RESISTORS XXX ARE 1%, MF., 1/8 W.

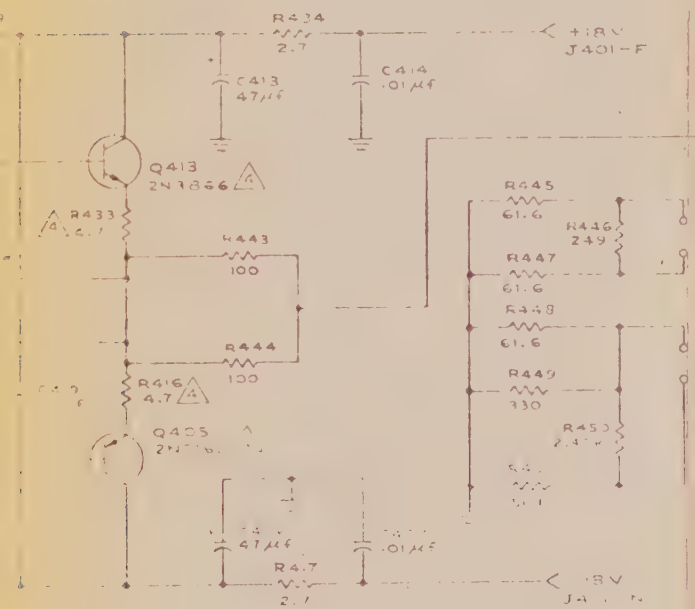
1. ALL RESISTORS XX ARE 10%, C.C., 1/4 W.

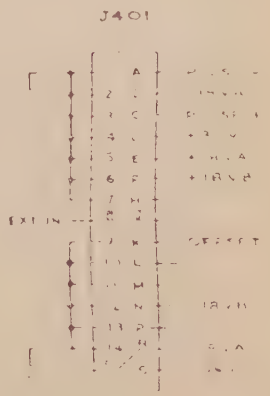
NOTES: UNLESS OTHERWISE SPECIFIED

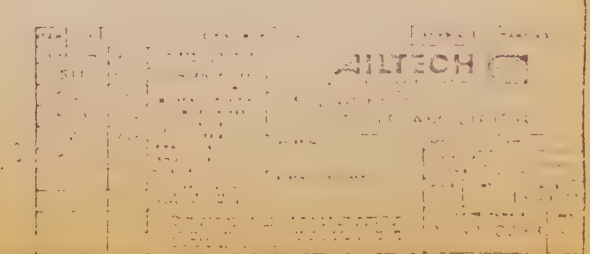
4 ON S/N [illegible] UNITS, COMPONENTS NOTED 4 ARE REPLACED WITH:

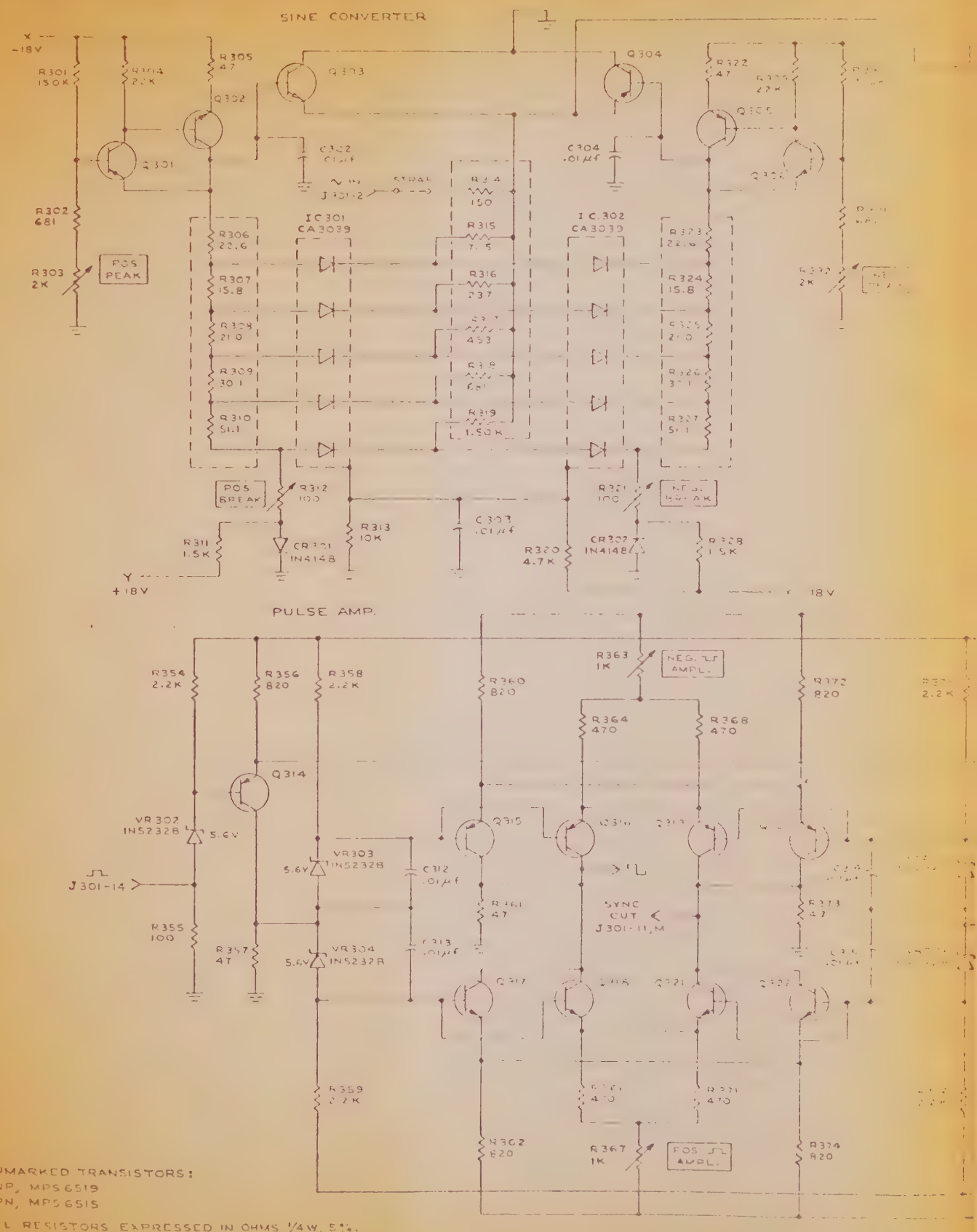
Q404	2N2222A
Q405	2N5962A
Q412	2N5962A
Q413	2N2219A
R410	10Ω
R433	10Ω


R435
15
R437
330
R438
3.1K
R436
27
Q415
2N2219A
R440
1.5K
R439
1.5K
C415
47μf
Q416
MPS3904
+36V
J401-D
+18
J401-E


R434
2.7
+18V
J401-F
C413
47μf
C414
.01μf
Q413
2N1866
R433
4.7
R443
100
R444
100
R416
4.7
Q405
R445
61.6
R446
249
R447
61.6
R448
61.6
R449
330
20 DB
S401
40 DB
S402
OUTPUT
C412
47μf
C411
.01μf
R417
2.7
-18V


J401
EXT IN

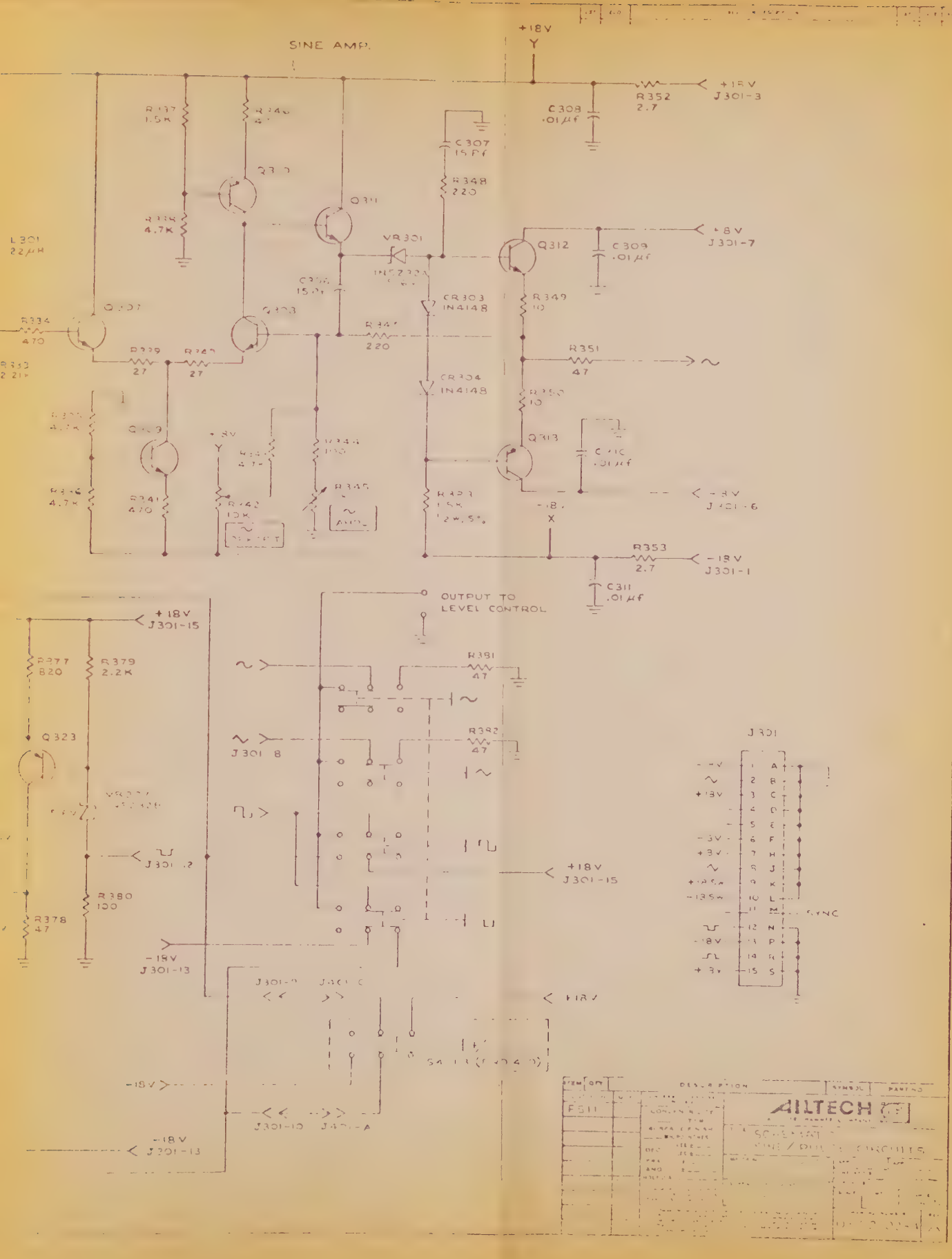

AILTECH

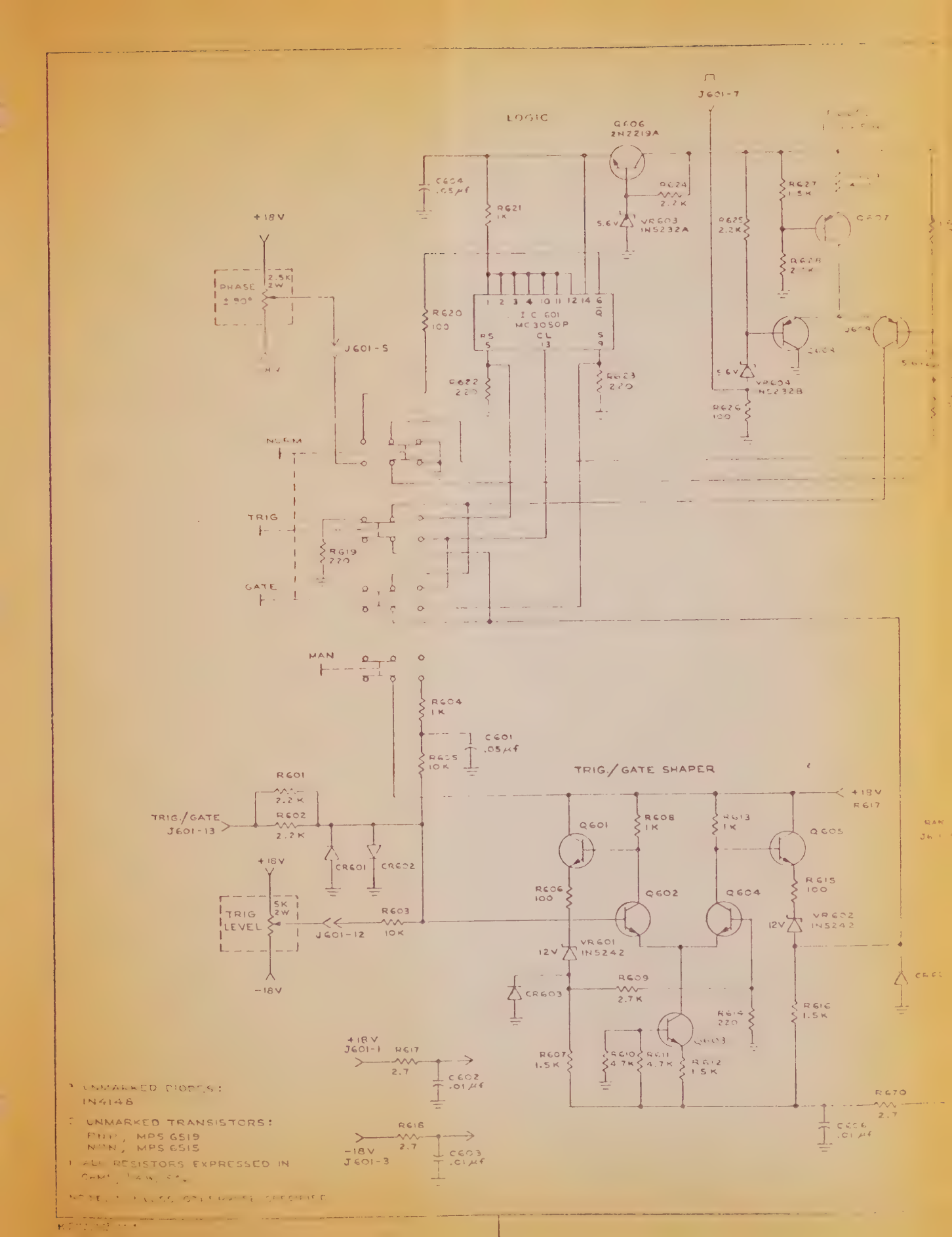


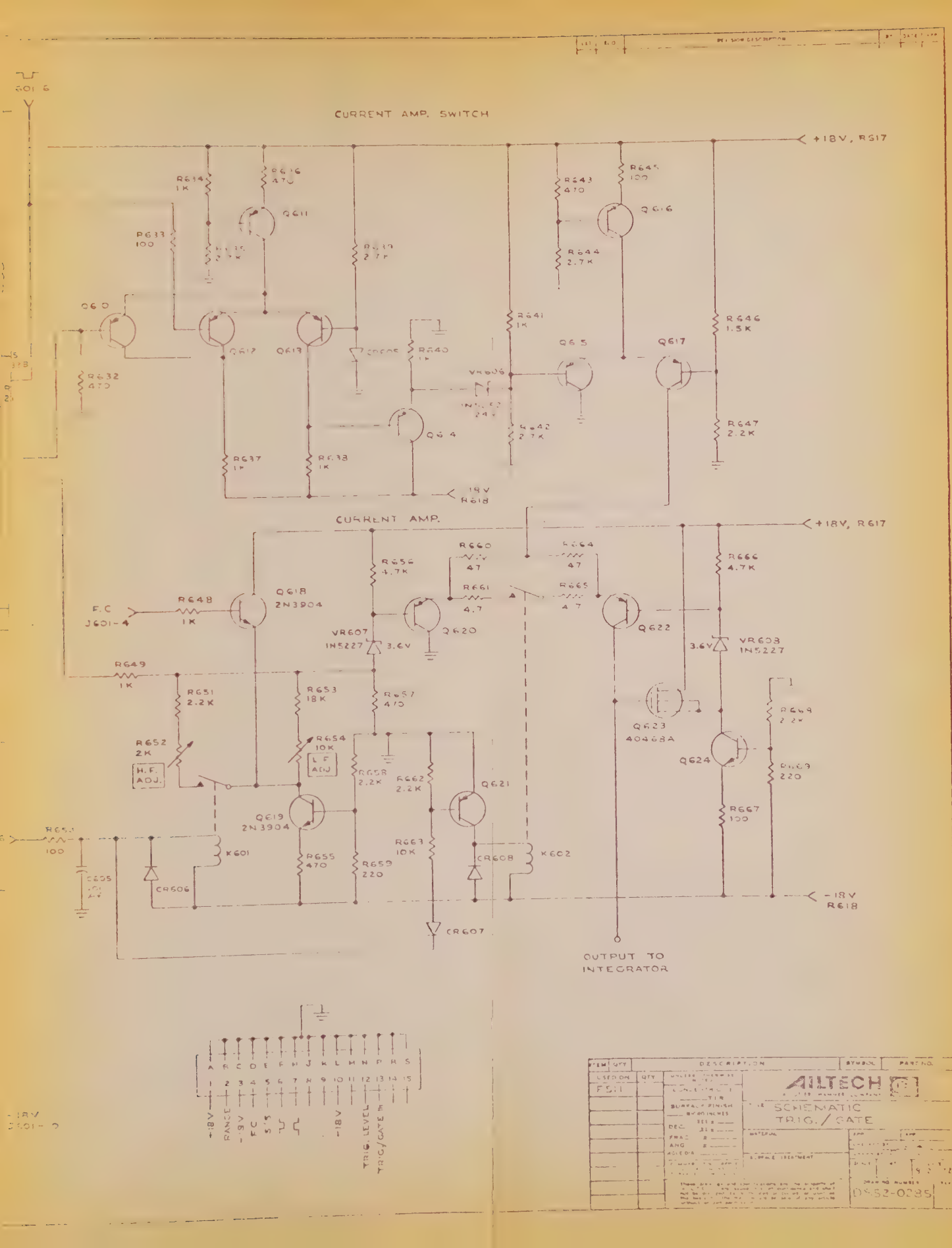
2. UNMARKED TRANSISTORS:
PNP, MPS6519
NPN, MPS6515

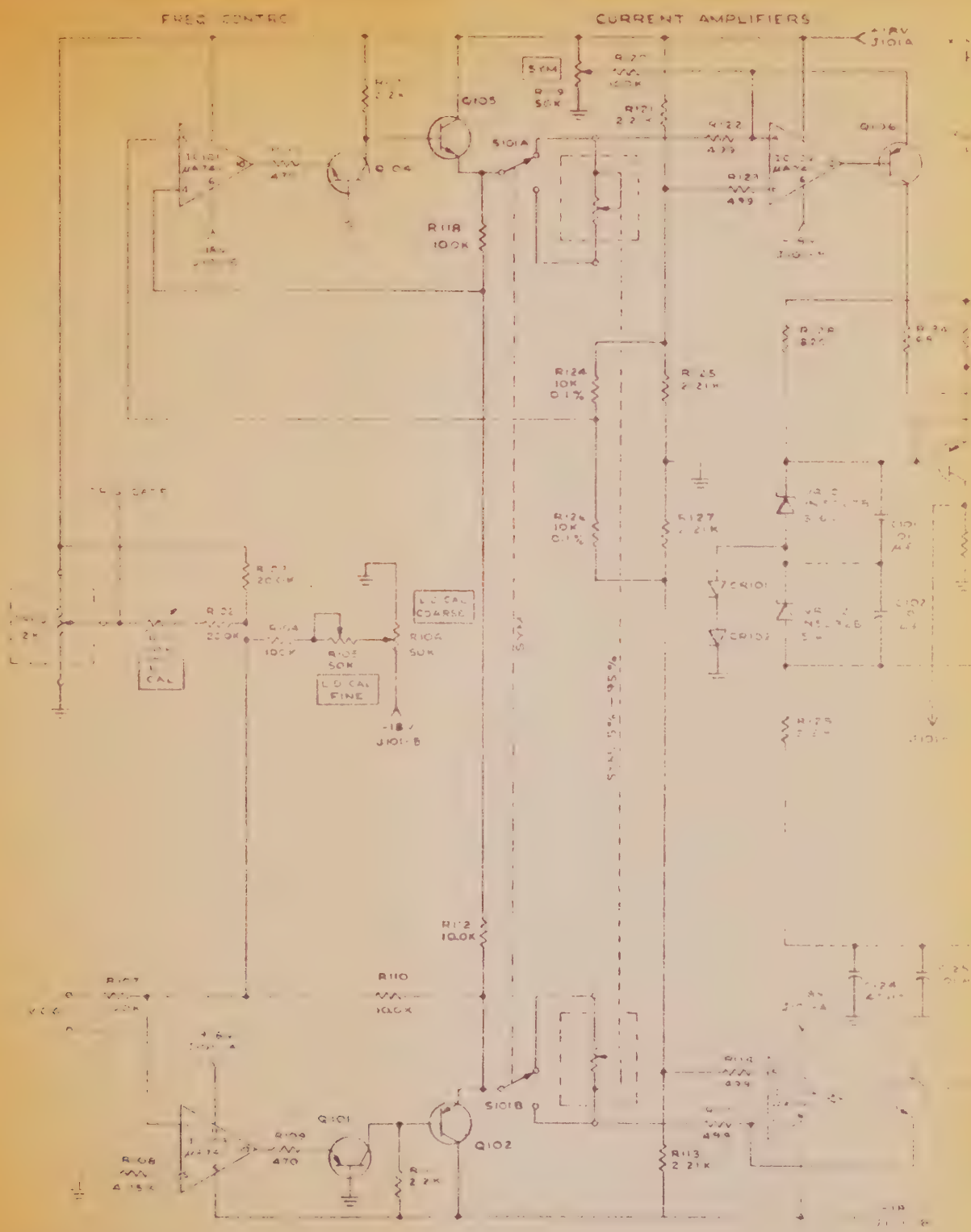
1. ALL RESISTORS EXPRESSED IN OHMS, ¼W, 5%.

NOTES: UNLESS OTHERWISE SPECIFIED.

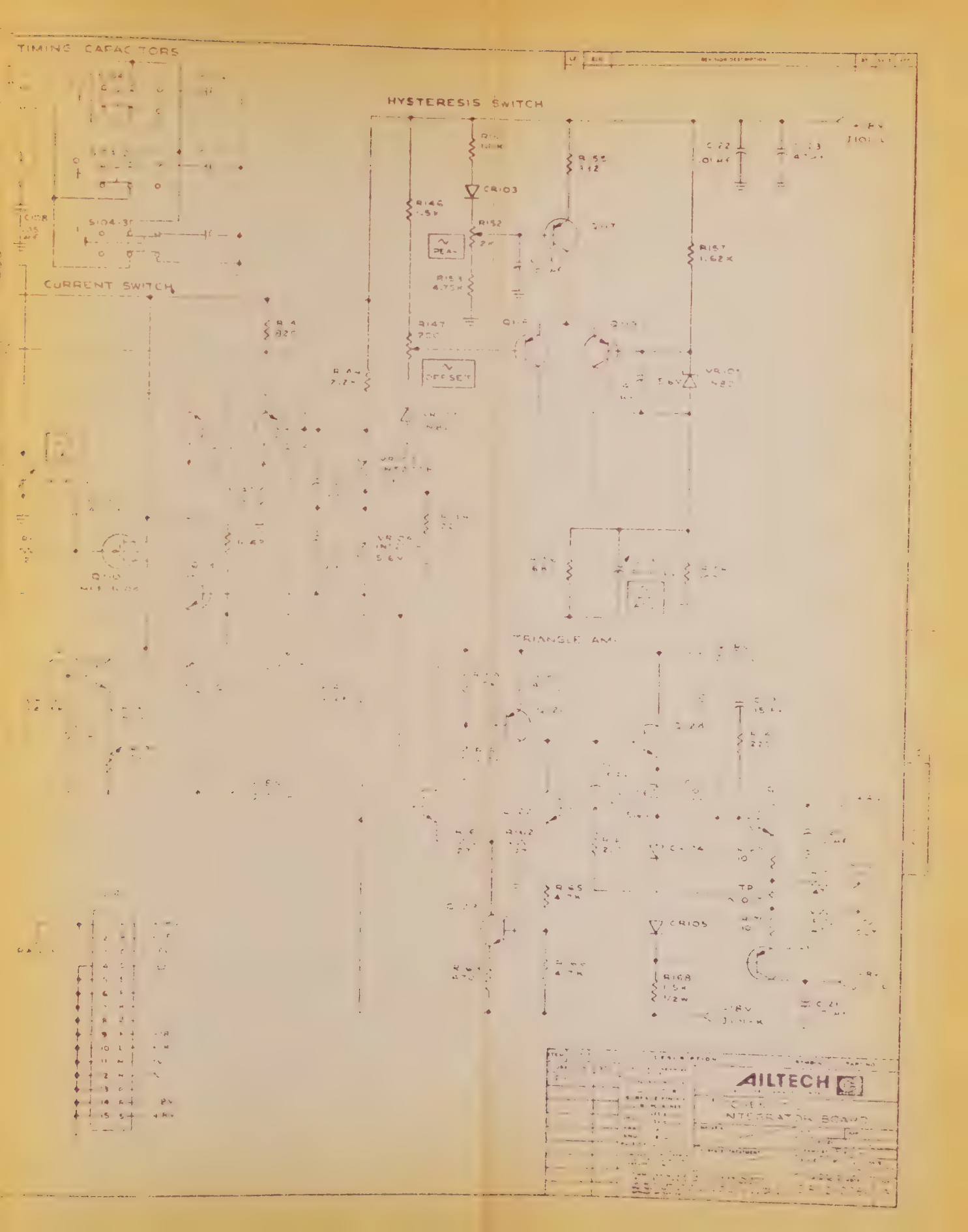

SINE AMP.
+18V
Y
R352
2.7
+18V
J301-3
C308
.01μf
C307
15 Pf
R348
220
Q311
VR301
IN5232A
L301
22μH
Q312
C309
.01μf
+8V
J301-7
R334
470
Q307
Q308
R339
27
R340
27
C306
15 Pf
CR303
IN4148
R347
220
R349
10
R351
47
CR304
IN4148
R350
10
Q313
C310
.01μf
R341
470
R342
10K
R345
R343
1.5K
1/2W, 5%
-8V
J301-6
-18V
X
R353
2.7
-18V
J301-1
C311
.01μf
OUTPUT TO
LEVEL CONTROL
+18V
J301-15
R377
820
R379
2.2K
R381
47
R382
47
Q323
J301-8
J301-12
R380
100
R378
47
-18V
J301-13
+18V
J301-15
J301
GND
SYNC
-18V
+18V
-18V
J301-13
AILTECH
SCHEMATIC
SINE / SQUARE CIRCUITS

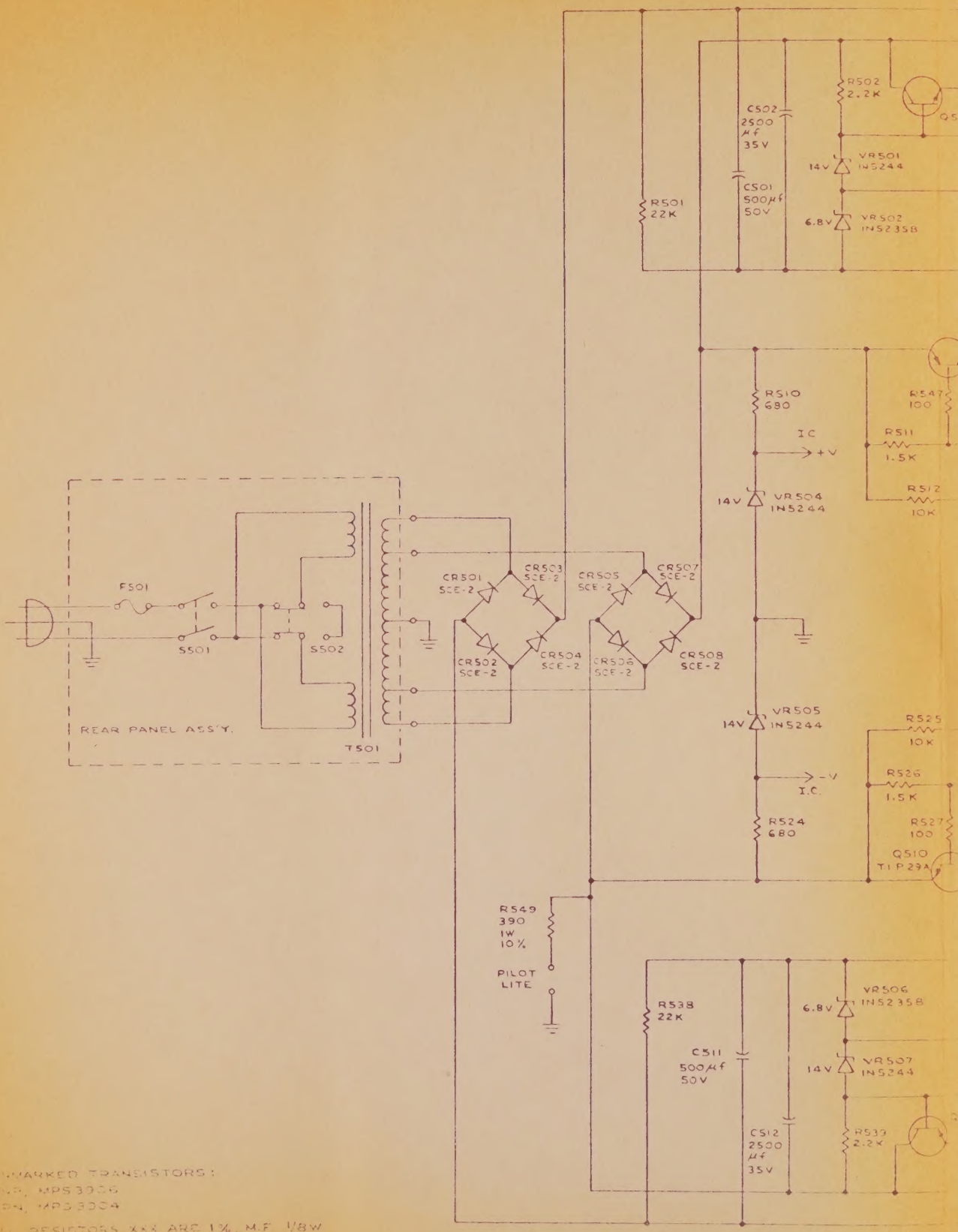

LOGIC
J601-7
Q606 2N2219A
C604 .05μf
R621 1K
R624 2.2K
5.6V
VR603 IN5232A
+18V
PHASE ± 90°
2.5K 2W
J601-5
R620 100
IC 601 MC3050P
1 2 3 4 10 11 12 14 6
R622 220
R623 220
R625 2.2K
R627 1.5K
R628 2.7K
Q607
Q608
J609
5.6V
VR604 IN5232B
R626 100
NORM
TRIG
GATE
R619 220
MAN
R604 1K
C601 .05μf
R605 10K
TRIG./GATE SHAPER
R601 2.2K
TRIG./GATE J601-13
R602 2.2K
CR601
CR602
+18V
TRIG LEVEL
5K 2W
R603 10K
J601-12
-18V
Q601
R608 1K
R613 1K
Q605
+18V R617
R606 100
Q602
Q604
R615 100
VR602 IN5242
12V
VR601 IN5242
12V
CR603
R609 2.7K
Q603
R614 220
R616 1.5K
R607 1.5K
R610 4.7K
R611 4.7K
R612 1.5K
+18V J601-1
R617 2.7
C602 .01μf
R618 2.7
-18V J601-3
C603 .01μf
R670 2.7
C606 .01μf
UNMARKED DIODES: IN4148
UNMARKED TRANSISTORS: PNP, MPS 6519 NPN, MPS 6515
ALL RESISTORS EXPRESSED IN


CURRENT AMP. SWITCH
+18V, R617
R614 1K
R616 470
Q611
R633 100
R639 2.7K
R643 470
R645 100
Q616
R644 2.7K
Q610
Q612
Q613
R640 1K
R641 1K
Q615
Q617
R646 1.5K
R632 470
VR606 1N5242 12V
R642 2.7K
R647 2.2K
Q614
R637 1K
R638 1K
-18V R618
CURRENT AMP.
+18V, R617
R656 4.7K
R660 47
R664 47
R666 4.7K
F.C J601-4
R648 1K
Q618 2N3904
R661 4.7
R665 4.7
Q620
Q622
VR607 1N5227 3.6V
VR608 1N5227 3.6V
R649 1K
R651 2.2K
R653 18K
R657 470
Q623 40468A
R669 2.2K
R652 2K
H.F. ADJ.
R654 10K
L.F. ADJ.
R658 2.2K
R662 2.2K
Q621
Q624
R668 220
Q619 2N3904
R667 100
R650 100
K601
R655 470
R659 220
R663 10K
CR608
K602
C605 .01 MF
CR606
-18V R618
CR607
OUTPUT TO INTEGRATOR
A B C D E F H J K L M N P R S
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
+18V
RANGE
-9V
FC
-18V
TRIG. LEVEL
TRIG/GATE
SCHEMATIC TRIG./GATE
AILTECH
D852-0285



1. UNMARKED DIODES: 1N4148
2. UNMARKED TRANSISTORS
   FET: MPF102
   NPN: MPS6515
4. RESISTANCE IN OHMS, 1/4W, 5%
5. UNLESS OTHERWISE NOTED, CAPACITANCE


TIMING CAPACITORS
HYSTERESIS SWITCH
CURRENT SWITCH
TRIANGLE AMP
CR103
CR105
PEAK
OFFSET
AILTECH
INTEGRATOR BOARD

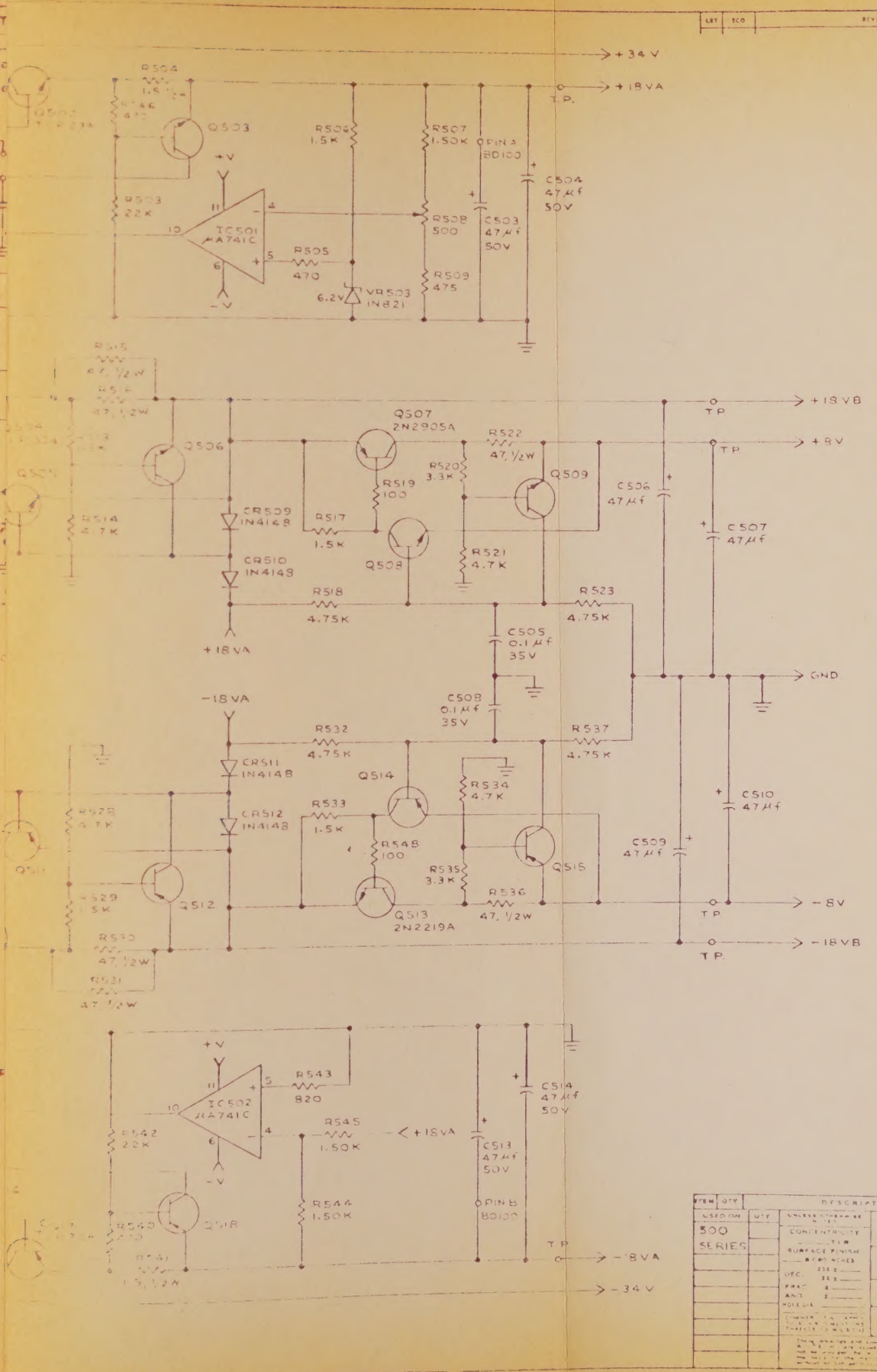


3. UNMARKED TRANSISTORS:
   PNP, MPS3906
   NPN, MPS3904

2. ALL RESISTORS xxx ARE 1%, M.F., 1/8W

1. ALL RESISTORS xx ARE 10%, CC, 1/4W

NOTES: UNLESS OTHERWISE SPECIFIED



ITEM	QTY	DESCRIPTION	SYMBOL	PART NO.
USED ON	QTY	UNLESS OTHERWISE SPECIFIED		
500 SERIES		CONCENTRICITY T.I.R.	AILTECH	
		SURFACE FINISH R.M.S. MAX.	TITLE SCHEMATIC MASTER BOARD	
		DEC. .XX ± .XXX ±		
		FRAC. ±		
		ANG. ±		
		HOLE SIZE		
		FINISH TREATMENT		
			DRAWN BY	DATE 4-30-72
			DRAWING NUMBER	REV
			D552-0287	A

AILTECH
A CUTLER-HAMMER COMPANY

WARRANTY

Except for tubes, crystals, semiconductors, fuses and batteries which carry no warranty, AILTECH, in connection with equipment sold, agrees to correct any defect in workmanship or material which may develop during the period of one year from the date of shipment under proper or normal use and not in excess of of the original manufacturer's life expectancy ratings, by its option to repair or to replace, F.O.B. point of shipment, the defective part or parts, and such correction shall constitute a fulfillment of all AILTECH liabilities in respect to said apparatus.